EnviStats India 2019

Volume - II Environment Accounts

GOVERNMENT OF INDIA
MINISTRY OF STATISTICS AND PROGRAMME IMPLEMENTATION
NATIONAL STATISTICAL OFFICE
(SOCIAL STATISTICS DIVISION)

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Acknowledgement
The Division gratefully acknowledges the contribution of all the source agencies, without whom this multifarious collection of statistics could not have been possible.

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PRAVIN SRIVASTAVA
Secretary & Chief Statistician of India

सत्यमेव जयते

150 YEARS OF CELEBRATING THE MAHATMA

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Government of India
सांख्यिकी एवं कार्यक्रम कार्यान्वयन मंत्रालय
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FOREWORD

The Rio conventions on biodiversity, climate change and desertification and the 2030 Agenda for Sustainable Development have brought to fore the requirement of integrating social, economic and environmental data and information with the decision-making processes. The ***System of Environment-Economic Accounting (SEEA)*** is envisaged to support the assessment of not just the environmental assets or ecosystems and their sustainability but also the two-way cause-effect relationship between environment and the economy. These accounts can inform on the progress made by the economy on a multitude of targets envisioned under the Sustainable Development Goals, relating to environment and climate change, agriculture, energy and sustainable production and consumption.

The National Statistical Office had, in 2018, released a publication giving the time-series asset accounts of some of the natural resources across the States of India. In the current publication, the dimension of quality on these 'quantities' of natural resources have been added and includes prescriptions on the methods that can be used for understanding the quality of soil and water. Also, the contribution of nature in two important economic activities – agriculture and tourism have been viewed through the lens of ecosystem services in the current publication.

The possibilities of interpreting 'nature' as accounts are limitless, just like 'nature' itself. The National Statistical Office is committed to help in making the comprehension easier for all stakeholders, so that evidence-based policy making can ensure a sustainable future and more accounts can be expected in future issues of this publication.

I take this opportunity to congratulate the team of officers of the Social Statistics Division of NSO for this publication and also for following the quote, "what gets measured, gets monitored" in letter and spirit.

(Pravin Srivastava)

New Delhi
September, 2019

असित कुमार साधु
महानिदेशक (एस.एस.)
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सत्यमेव जयते

150 YEARS OF CELEBRATING THE MAHATMA

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PREFACE

The System of Environment-Economic Accounting (SEEA) - Central Framework was adopted as an international standard for environmental-economic accounting by the United Nations Statistical Commission, at its 43rd session in 2012. The SEEA framework helps in understanding the interactions between the environment and the economy by describing the changes in stocks of environmental assets vis-a-vis the economic activities. By incorporating internationally agreed concepts and definitions on environmental-economic accounting, it has become an invaluable tool for compiling integrated statistics, deriving coherent and comparable indicators and measuring progress towards sustainable development goals.

Environmental Accounting for a mega-diverse country like India is packed with challenges - from requirements of huge datasets and several microscopic studies to synchronising all of these so that they speak to each other and can yield consistent estimates. An implementation plan for environment accounting was drawn by the Expert Group on "Green National Accounts in India", constituted under the Chairmanship of Prof. Sir Partha Dasgupta. The report of the Expert Group listed not just short-term activities which could be undertaken using existing datasets and but also long-term ones, for which implementation plans would need to be drawn up.

In pursuance of the recommendations of the Expert Group, the first publication on "Environmental Accounts", giving the asset accounts of four main natural assets - land, forests, water and minerals was released last year. This year's publication is, in parts, a continuation of the earlier one, since it focusses on assessment of quality of soil and water as also valuation of the ecosystem services provided by cropland.

The data given in this publication is based on the information sourced from the Ministries/ Departments/ Organizations of Central Governments. I express my deep gratitude to all data source agencies which contributed the valuable data /information and supported our efforts to bring out the publication.

Suggestions for further improvement of the publication are welcome and will be highly appreciated.

New Delhi
September 2019

(A. K .Sadhu)
Director General

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The Social Statistics Division of the National Statistical Office gratefully acknowledges the contribution of all the members of the Inter-Ministerial Group on Environmental-Economic Accounting, whose suggestions and comments have helped enrich this publication and improve its usefulness. The Division acknowledges the contribution of all the source agencies listed below for the data on different aspects of environment as also the support and guidance provided on methodological issues for this publication on Environmental Accounts:

1. Integrated Nutrient Management Division and Directorate of Economics & Statistics of the Department of Agriculture, Cooperation & Farmers Welfare; Soil and Land Use Survey of India, National Bureau for Soil Survey and Land Use Planning and other Divisions/ Organisations of the Ministry of Agriculture & Farmers Welfare;
2. Central Water Commission, Central Ground Water Board and the Divisions of the Ministry of Water Resources, River Development and Ganga Rejuvenation;
3. National Council for Coastal Research, Ministry of Earth Sciences;
4. National Remote Sensing Centre, Ministry of Space;
5. Ministry of Tourism; and
6. Survey of India.

Acknowledgments are also due to United Nations Statistics Division (UNSD) and United Nations Environment Programme (UN Environment) for their technical guidance at various stages of compilation and for spearheading the project on 'Natural Capital Accounting and Valuation of Ecosystem Services' piloted by the European Union in India, which has provided a valuable forum for collaborating with the subject-matter experts, which is vital for any discussion on 'environment'.

The Division is also thankful to all the named and unnamed contributors of the material used for this publication and the permissions granted for copyright material. While every effort has been made, it has not always been possible to identify the sources of all the material used, or to trace all copyright holders. The Division shall ensure inclusion of the appropriate acknowledgements/references on reprinting if any omissions are brought to its notice.

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Acronyms and Abbreviations

A	**AGB**	Above Ground Biomass
	APY	Area, Production and Yield
B	**BCM**	Billion Cubic Meters
	BGB	Below Ground Biomass
	bgl	Below Ground Level
C	**CACP**	Commission for Agricultural Costs and Prices
	CCA	Culturable Command Area
	CCS	Cost of Cultivation Studies
	CFS	Cubic Feet per Second
	CGWB	Central Ground Water Board
	CIFOR	Center for International Forestry Research
	CMR	Coal Mines Regulation
	COMAPS	Coastal Ocean Monitoring and Prediction System
	CPCB	Central Pollution Control Board
	Cu. m	Cubic Meter
	cumecs	Cubic Meter per Second
	CWC	Central Water Commission
D	**DES**	Directorate of Economics and Statistics
	DIN	Dissolved Inorganic Nitrogen
	DIP	Dissolved Inorganic Phosphorus
	DOD	Department of Ocean Development
	DOS	Department of Space
E	**EARAS**	Establishment of an Agency for Reporting of Agricultural Statistics
	EEA	Experimental Ecosystem Accounts
F	**FAO**	Food and Agriculture Organization
	FSI	Forest Survey of India
G	**GOI**	Government of India
	GPG	Good Practice Guidance
H	**Ha**	Hectare
I	**IMG**	Inter-Ministerial Group
	IPC	Irrigation Potential Created
	IPCC	Intergovernmental Panel on Climate Change
	IPU	Irrigation Potential Utilized

	IUSS	International Union of Soil Science
K	**km**	Kilometre
L	**LC**	Land Cover
	LU	Land Use
	LULC	Land Use and Land Cover
	LULCF	Land Use, Land-Use Change, and Forestry
M	**M. ha.**	Million Hectare
	MI	Micro Irrigation
	mm	Millimetre
	MoEF&CC	Ministry of Environment, Forest and Climate Change
	MoES	Ministry of Earth Sciences
	MSPs	Minimum Support Prices
N	**N.I**	Nutrient index
	NBS	Nutrient-based Subsidy
	NCCR	National Centre for Coastal Research
	NCIWRD	National Commission on Integrated Water Resources Development
	NPV	Net Present Value
	NRC	Natural Resources Census
	NRR	Natural Resources Repository
	NRSA	National Remote Sensing Agency
	NRSC	National Remote Sensing Centre
	NSO	National Statistical Office
	NSS	National Sample Surveys
O	**OW**	Observation Well
P	**PACS**	Primary Agricultural Credit Society
	PM-AASHA	Pradhan Mantri Annadata Aay Sanrakshan Abhiyan
R	**RR**	Resource Rent
S	**SHCs**	Soil Health Cards
	SRU	Standard River Units
	STL	Soil Testing Labs
	SWQM	Seawater Quality Monitoring
U	**UNWTO**	UN World Tourism Organization
	UNWWAP	United Nations World Water Assessment Programme
	UPR	Usual Place of Residence
W	**WQI**	Water Quality Indices

Introduction

Chapter 1

Introduction

The environment and the economy are really two sides of the same coin. If we cannot sustain the environment, we cannot sustain ourselves.

Wangari Maathai

Background

The Indian tradition and ethos stress on the fact that human being is part of a well-ordered system in which all aspects of life and nature have their place, and are not in opposition, but in harmony with each other. However, this harmony is getting affected by the increased demand on natural resources being created with industrialization and urbanisation getting clubbed with the effects of climate change. Since India is now in a phase of demographic dividend, where the working-age population outnumber dependant population, a positive influence on growth and development is expected to follow. The key, however, is to ensure that this spurt in growth remains sustainable and that the country is able to retain the natural wealth required for its economic activity and well-being. Not surprisingly, therefore, while policies and schemes are being evolved in India for provision of clean drinking water and increased use of technology for the benefit of small scale producers and farmers, conservation measures like those of rainwater harvesting by panchayats and checks on incessant use of chemical fertilizers and single use plastics are also being vigorously implemented.

2. The push towards integrating the information on economic activities with those on environment is greater than ever before, notwithstanding the challenges of getting the adequate information to do so. It is imperative that the links between "nature", the services it provides, the disservices being caused and the economic prosperity are understood so that the environmental limits are known before the tipping points are reached. Understanding that sustainable economic development can only be achieved by respecting these limits, can help create win-wins for both environment and the economy.

Sustainable Development and SEEA

3. When the United Nations adopted the "2030 Agenda for Sustainable Development" in September 2015, global goals were agreed for a sustainable economic, social and ecological transformation of our world. The key strategic themes of the 2030 Agenda for this shift towards greater prosperity and peace for the people and the planet were, amongst others, environmental challenges such as climate change or the conservation of oceans and forests. A major challenge is the monitoring of the Sustainable Development Goals – which requires understanding the objectives assigned to the individual goals and translating them into indicators which can be tracked by the public and policymakers alike.

4. The System of Environmental Economic Accounting (SEEA), the statistical framework for environment accounts, can cover a wide range of environmental data and environmental information requirements, including those on the SDG indicators required to indicators to monitor the progress towards achieving the goals and targets. Some of the SEEA accounts which can inform on the different SDGs have been depicted in **Figure 1.1** below.

Figure 1.1: Linkage between SEEA and SDG

	**SEEA-Agriculture, Forestry and Fisheries / SEEA-Experimental Ecosystem Accounting**
	**SEEA-Water / SEEA-physical supply and use tables for water/ SEEA-land accounts / SEEA- ecosystem accounts**
	**SEEA-Energy**
	**Material flow accounts / SEEA and tourism satellite accounts**
	**SEEA-emission accounts**

11 SUSTAINABLE CITIES AND COMMUNITIES	**SEEA-land accounts / SEEA-environmental protection expenditure accounts / SEEA- emission accounts**
12 RESPONSIBLE CONSUMPTION	**SEEA-material flow accounts, water accounts, energy accounts and other resource specific accounts / SEEA-solid waste accounts / SEEA and tourism satellite accounts**
14 LIFE BELOW WATER	**SEEA-Agriculture, Forestry and Fisheries / SEEA-emissions accounts / SEEA-accounts for aquatic resources / SEEA-land accounts / SEEA-environmental taxes and subsidies accounts**
15 LIFE ON LAND	**SEEA-land accounts / SEEA-Agriculture, Forestry and Fisheries / ecosystem accounts (ecosystem condition accounts, ecosystem service accounts and biodiversity accounts)**

Environment Accounts in India

5. The National Statistics Office under the Ministry of Statistics and Programme Implementation is mandated with "Development of Environment Statistics; and Development of methodology, concepts and preparation of National Resource Accounts for India". In this context, an Expert Group had been constituted under the chairmanship of Sir Partha Dasgupta for advising on an implementation plan for compiling "Green National Accounts in India". Several deliberations with numerous data sources followed the acceptance of the recommendations of the Expert Group by the Government. The first layers of these accounts were collated and released in the year 2018, in the publication, EnviStats India 2018 – Supplement on Environmental Accounts, detailing the physical asset accounts, at the state and national levels, of land cover, minerals, water and forests.

6. The next logical step would be to convert these physical accounts to monetary accounts. But true to the proverbial quote that "nature holds many secrets", details need to be added for each of the assets about their quality characteristics, before a valuation exercise can be attempted. Recognising the fact that the main objective of these accounts is to aid in monitoring changes in the stock of natural capital in terms of its capacity to continue to deliver ecosystem services, the System of Environmental Economic Accounting gives some examples of quality characteristics which can affect capacity:

- relevant volume estimates (for example, timber biomass, water quantity or flow, length of linear features)
- biodiversity indicators (for example, abundance indicators, mean species richness)
- soil indicators (for example, carbon content, water content)

- ecological condition indicators (for example, water quality, plant health, invasive species)
- spatial configuration (for example, fragmentation, connectivity)
- access (for example, proximity to areas of population)
- management practices (for example, organic farming, degree of protection)

7. The current issue of EnviStats India, 2019, envisages to add some of these layers on the quality characteristics, namely, soil nutrient index and water quality accounts in respect of surface, ground and sea water. In addition, to help understand the contribution of ecosystem services to the economy, values of two ecosystem services have been compiled for all the States of the country – cropland ecosystem services and nature-based tourism. A brief overview of the remaining chapters is given in the following paragraphs.

Chapter 2. Soil Nutrient Indices

8. Soil is the foundation of all terrestrial ecosystems and the agricultural and forestry provisioning services, as well as being the structural medium for supporting the terrestrial biosphere and human infrastructure. Soil gives plants the foothills for their roots and holds the necessary nutrients to grow plants, provide habitat for many insects and other organisms, filters the rain water and controls the discharge of excess rain water along with flooding. Also it is capable of storing large amounts of organic carbon and buffers against pollutants thus protecting groundwater quality. Healthy soils increase the capacity of crops to withstand weather variability, including short term extreme precipitation events and intra-seasonal drought. Soil fertility, or the soil's reserve of crop nutrients, is broadly equated with soil quality and soil health. With around 60% of the rural households in India still being dependent on agriculture, soil health has been one of the prime focus areas of the Government.

9. Under the Soil Health Card Scheme of Ministry of Agriculture and Farmers Welfare, Government of India, soil health condition is assessed w.r.t. 12 important soil parameters namely – Nitrogen, Phosphorus, Potassium (Macro-nutrients), Sulphur (Secondary-nutrient), Zinc, Iron, Copper, Manganese, Boron (Micro-nutrients) and pH, Electric Conductivity, Organic Carbon (Physical Parameters). Soil samples collected from different locations are analysed in the Soil Testing Labs (STL) and Soil Health Cards (SHCs) generated along with fertilizer recommendations for the sampled plot. The test results are available in public domain at www.soilhealth.dac.gov.in. In this publication, the information made available through about 2 crore soil samples each collected under cycle I (2015-16 to 2016-17) and cycle II (2017-18 to 2018-19) of the Soil Health Card Scheme has been analysed to enable an assessment of the existing status and trends of macro and micro nutrients in different states/UT's of the country.

Chapter 3. Water Quality Accounts

10. Water resources across the world are under severe environmental stress due to the growing population and increased levels of developmental activities, industrialization and urbanisation. In India, with a high dependence on agriculture, intensive irrigation is also added to the list, accelerating the usage of large quantity of surface water as well as groundwater for various purposes. Worsening the water woes is an increase in disposal of solid waste from urban and industrial hubs which has posed a threat for environment due to unprecedented discharges into natural water sources and indiscriminate dumping in the agricultural fields. Therefore, despite the development of water resources with space and time, there is a huge gap between demand and availability of water of desired quality. Water Quality Accounts are one of the most effective ways to describe the quality of water and to assist in the formulation of appropriate policies by various environmental agencies. These accounts not only allow for comparability across water bodies or across time periods, but can also be used in assessments of the impacts of pollution and can help evaluate the policies aimed at decreasing pollution or improving the state of water bodies. In Section I of this chapter, Water Quality Accounts, in respect of Surface Water, have been prepared for Godavari River Basin for the year 2015-16 using site-wise month-wise information as obtained from Central Water Commission (CWC). The chapter also includes Water Quality Accounts for groundwater for the States of Punjab and Haryana for the year 2015 that were compiled using the data provided by Central Ground Water Board (CGWB).

Chapter 4. Coastal Water Quality Index

11. In order to complete the coverage of quality of different types of water, Water Quality Indices, as compiled by the National Council for Coastal Research, for the period 2011-15 across the coastline of the country have been given in this chapter.

Chapter 5. Valuation of Cropland Ecosystem Services

12. Agriculture is a key sector of the economy and is vital to not just food and non-food production, but also to rural development and poverty alleviation. The ecosystem services provided by cropland in the provisioning of crops are the total and combined result of processes taking place in cropland that support crop production such as infiltration of water, the water holding capacity of the soil, the absorption of plant nutrients by soil particles and the resupply of these particles to plants. The measurement of Resource Rent provides a gross measure of the value of this cropland ecosystem service to crop production. In this chapter, district-wise estimates of the value of cropland ecosystem service per unit of net area sown and per unit of geographic area of the district, have been presented for the years 2005-06, 2011-12 and 2014-15. The estimates have been compiled

using the 'appropriation method' prescribed by SEEA, where resource rent has been equated to sum of the rental value of owned land and rent paid for leased-in land, using the information available in the Cost of Cultivation Studies conducted by the Ministry of Agriculture and Farmers Welfare, as also the data on area and production of different crops released by the same Ministry.

Chapter 6. Valuation of Nature-Based Tourism

13. SEEA envisages to integrate the transactions between environment and the economy and the effect of these transactions on the two domains, in such a way to allow for analysis of the impact of different policy interventions. Nature-based tourism is one of the classical examples of the interaction between environment and economy, where the economic activity of 'tourism' is affected by the status of 'environment' and at the same time, also affects the state of 'environment'. In this chapter, an assessment of the current flow of nature-based tourism services has been made for the States of India using estimates based on a direct expenditure method, by combining information on average expenditure per person/day on a trip, the duration of stay, number of total visitors, total visitor expenditure (average expenditure per person/day x average length of stay x total visitor numbers) and the attribution factor (expenditure that can be directly attributed to the natural areas). It should be noted that the direct expenditure method provides only a conservative minimum estimate of the total economic contribution of natural areas as it excludes secondary expenditure such as local employment and does not include wider values of the benefits obtained from the environment. These benefits, however, could be calculated using the direct expenditure and other relevant indicators through a form of multiplier analysis.

14. All the chapters contain maps so as to provide a spatial context to the values. The exercise of compilation of water quality accounts or the soil health indices can be interpreted as a handholding exercise by NSO. The source agencies may use the methodology to improve the usefulness of the statistics provided by them. While facilitating inter-temporal and inter-spatial comparison, these indices can also help aggregate the detailed statistics being released in a manner to reflect the direction of the combined fluctuations in the different variables/monitoring sites. The publication "EnviStats-India" intends to provide the technical 'push' to the policy discussions in India, so that environmental information in mainstreamed to reshape government decision-making for a "better environment, better tomorrow".

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Soil Nutrient Indices

Chapter 2

Soil Nutrient Indices

A thin layer of soil covering the surface of the earth is the major interface between agriculture and the environment, and represents the difference between survival and extinction for most land based life.

J.W.Doran

Introduction

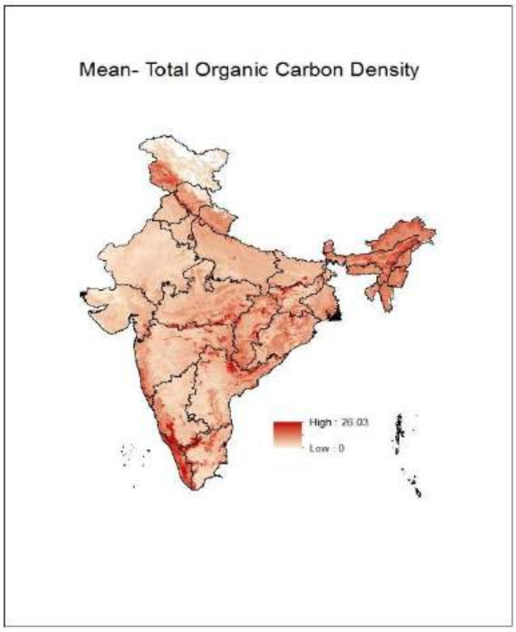
The term 'Soil' derived from Latin word 'Solum' is commonly defined as the top layer of the earth's crust, formed by mineral particles, organic matter, water, air and living organisms. It may look like dirty stuff that just holds plants in the ground, but actually it is very crucial for life. Soil is one of the most important natural resources that plays a vital role in the earth's ecosystem. It is the foundation of all terrestrial ecosystems and the agricultural and forestry provisioning services, as well as being the structural medium for supporting the terrestrial biosphere and human infrastructure[1]. Healthy soils increase the capacity of crops to withstand weather variability, including short term extreme precipitation events and intra-seasonal drought. Just like humans need a good diet to be healthy and strong, so do our soils. Soil ecosystem services are diverse, valuable, and underappreciated. It gives plants the foothills for their roots and holds the necessary nutrients to grow plants, provide habitat for many insects and other organisms, filters the rain water and controls the discharge of excess rain water along with flooding. Also it is capable of storing large amounts of organic carbon and buffers against pollutants thus protecting groundwater quality. They provide us with building materials as well as provide the structural foundation for human activities. In fact, soils are a source of many current medicines, probiotics and antibiotics.

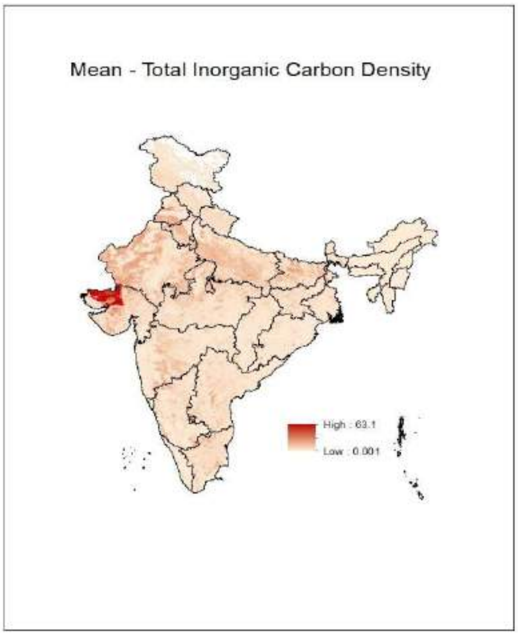
2. Soils are a major carbon reservoir comprising more carbon than the atmosphere and terrestrial vegetation combined. Soil Carbon is the backbone of soil fertility. Hence there is growing interest in assessing the role of soil as a source or sink for carbon emissions. Soil carbon includes both inorganic carbon as carbonate minerals, and as soil organic matter. Many tropical soils are poor in inorganic nutrients and rely on the recycling of

[1] Suzanne van der Meulen and Linda Maring (2018). Mapping and Assessment of Ecosystems and their Services: Soil ecosystems.

nutrients from soil organic matter. Soil organic carbon (SOC) is the engine of any soil and plays an important role in maintaining fertility by holding nitrogen, phosphorous and a range of other nutrients. It helps in improving soil properties such as water-holding capacity and providing gaseous exchange and root growth. The loss of SOC indicates a certain degree of soil degradation and soil degradation is a severe problem in countries like India with high demographic pressure. However, if more amount of carbon is stored in the soil as organic carbon, it will reduce the amount present in the atmosphere, and therefore help to alleviate the problem of global warming and climate change. The process of storing carbon in soil is called "soil carbon sequestration". Mapping of soil carbon densities across India was carried out by National Remote Sensing Centre (NRSC) using multi-temporal satellite data with an objective to provide important soil properties at 5 km equal area grid (start date: 1-9-2008 to stop date: 31-5-2012). The soil carbon density product consists of mean soil organic and inorganic carbon densities generated at 5000m spatial resolution[2] (**Figure 2.1**). These maps provide users with very useful information regarding soil condition and help in making decisions to mitigate and adapt to a changing climate.

Figure 2.1. Soil carbon density maps





3. Recognizing the significance of Soil, in December 2013, the UN General Assembly designated 5 December 2014 as the first official World Soil Day and now it is held annually on 5 December as a means to focus attention on the importance of healthy soil and advocating for the sustainable management of soil resources[3]. Also, the year 2015 was declared as International Year of Soils, (IYS 2015) with a theme "Healthy Soils for Healthy

[2] https://bhuvan-app3.nrsc.gov.in/data/download/tools/document/soil_nices.pdf

[3] http://www.fao.org/world-soil-day/about-wsd/en/

Life" by the Sixty-eighth session of the United Nations General Assembly on December 20th, 2013[4]. Furthermore, International Union of Soil Science (IUSS) has declared 2015-2024 as an International Decade of Soils.

Role of soils in achieving SDGs

4. It has been estimated that the current demographic trends and projected growth in global population (to exceed around 9 billion by 2050), will result in a 60 percent increase in demand for food, feed and fibre by 2050. Thus, protection of soil and land is essential for food security as well as the delivery of multiple other ecosystem services. In the year 2015, same year as the International Year of Soils, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development that includes 17 Sustainable Development Goals (SDGs). Zero hunger (Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture) is the most straightforward link that connects soils, food production, and healthy living. Moreover, improving soil quality is an integral step towards achieving the other SDGs such as No Poverty (Goal 1: End poverty in all its forms everywhere), Good Health and Well-being (Goal 3: Ensure healthy lives and promote well-being for all at all ages), Clean Water and Sanitation (Goal 6: Ensure availability and sustainable management of water and sanitation for all), Climate action (Goal 13: Take urgent action to combat climate change and its impacts), and Life on land (Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss).

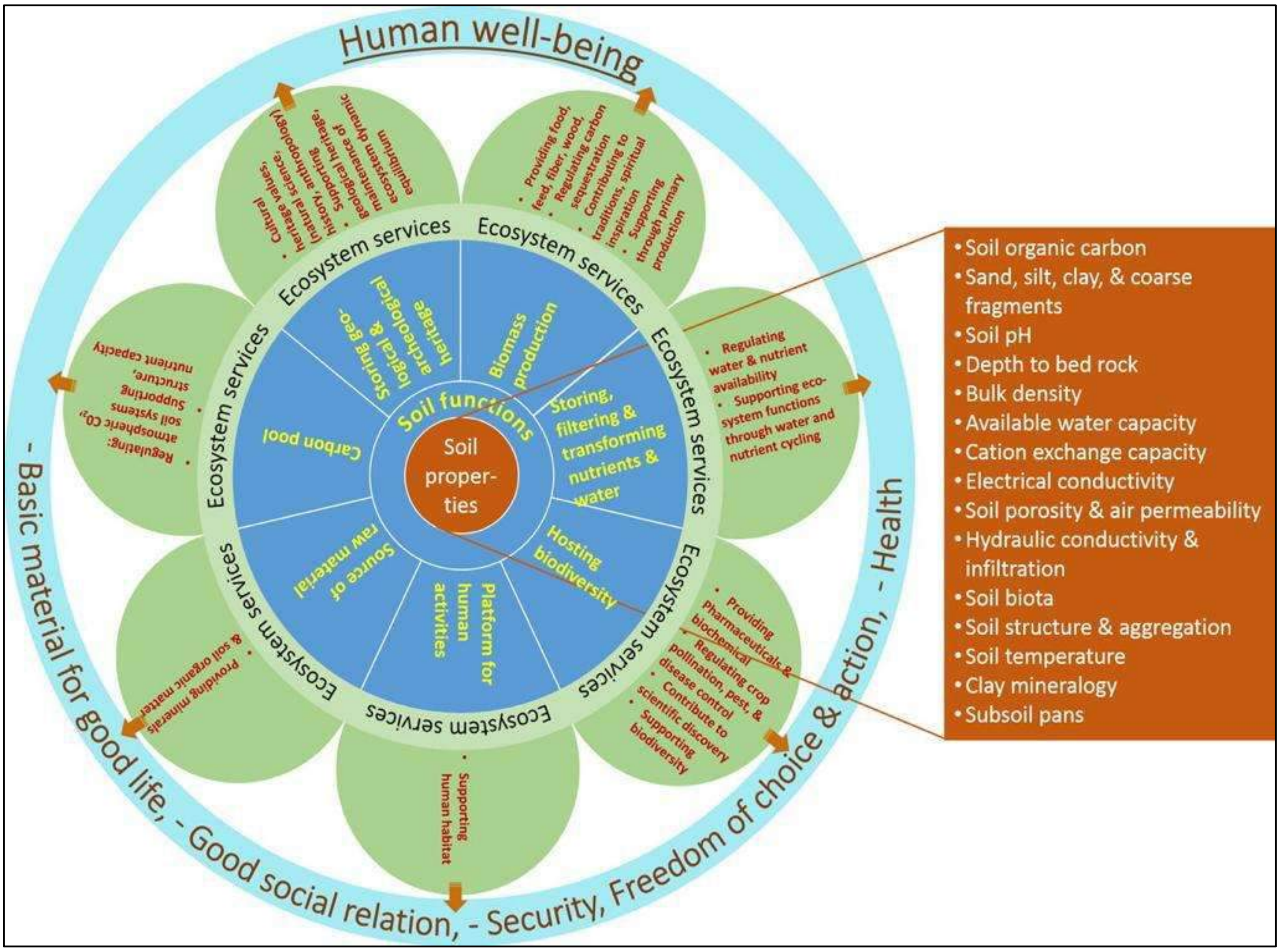
Soil as an Ecosystem

5. Soils are rich ecosystems, composed of both living and non-living matter with a multitude of interaction between them. Soil is one of the elements of natural capital that contribute to agricultural production, even though agricultural systems are not entirely natural systems. Farming combines the natural capital, soil, with manufactured capital, farm equipment, and human capital, farmer experience to produce crops. Soils are the source and foundation of ecosystem services that span the array of supporting, regulating,

[4] http://www.fao.org/soils-2015/about/en/

provisioning, and cultural services. **Figure 2.2** given below shows the linkage between key soil properties to ecosystem services through soil functions for the well-being of humans.

Figure 2.2. Linking soil properties to ecosystem services and human well-being



Source: K. Adhikari, A.E. Hartemink / Geoderma 262 (2016) 101–111

6. Supporting services are those that are necessary for other ecosystem services, such as soil fertility and its importance for food and fibre production. Regulating services control the environment in which we live. Provisioning services are the products made from soil, such as food and fibre, building materials, and pharmaceutical compounds. Cultural services are the non-material benefits we receive from soil, such as society's connection to a particular landscape[5].

Importance of Assessment of Soil Fertility Status

7. Soil fertility, or the soil's reserve of crop nutrients, is broadly equated with soil quality and soil health. Soil health is the capacity of soil to function as a vital living system,

[5] Stromberger, M., Comerford, N., & Lindbo, D. (2015). Soil Ecosystem Services and Natural Capital.

within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health. According to FAO, 95% of our food comes directly or indirectly from soil and it can take up to 1000 years to form just 2-3 cm of soil. But over the last 50 years, advances in agricultural technology and increased demand due to a growing population have put our soils under increasing pressure. In India, agriculture is the primary source of livelihood for about half of population and contributes around 18% to the country's Gross Domestic Product (GDP). Moreover, India is the world's largest producer of milk, pulses and jute, and ranks as the second largest producer of rice, wheat, sugarcane, groundnut, vegetables, fruit and cotton. It is also one of the leading producers of spices, fish, poultry, livestock and plantation crops. In all agricultural systems, significant amount of nutrients is removed over time in harvested products and these losses of nutrients can also occur due to soil erosion, runoff, leaching, burning of crop residues etc. Therefore, it is necessary to timely monitor the changes in the soils and study the soil dynamics to enhance the efficiency of applied nutrients to increase the agricultural productivity, thus, affecting the farmer's income in turn meeting with the government's target of doubling the farmer's income by 2022.

8. Soil types vary widely throughout the world, depending on location (geology, climate, vegetation) with corresponding variation in the combination of physical, chemical and biological properties. In India, there are various types of soils ranging from the fertile alluvial of the Indo-Gangetic plains to the black and red soils of the Deccan Plateau. In the ancient period, the soil used to be classified based on only two things: whether the soil is fertile (Urvara) or sterile (Usara). But now, soils are broadly classified as Red soil, Black soil, Lateritic soil, Alluvial soil, Desert soil, Forest and Hill soils. These soils differ in their productivity and need differential management practices. Assessment of fertility status of the soils of an area or a region is an important aspect in the context of sustainable agriculture. Intertemporal and interspatial analysis of the trends in nutritional status of soils will help in understanding the consequences of the present farming practices, as also in assessing the suitability of these soils for different policy formulations in future so as to ensure that this asset provides maximum benefit to farmers with minimal impact on environment.

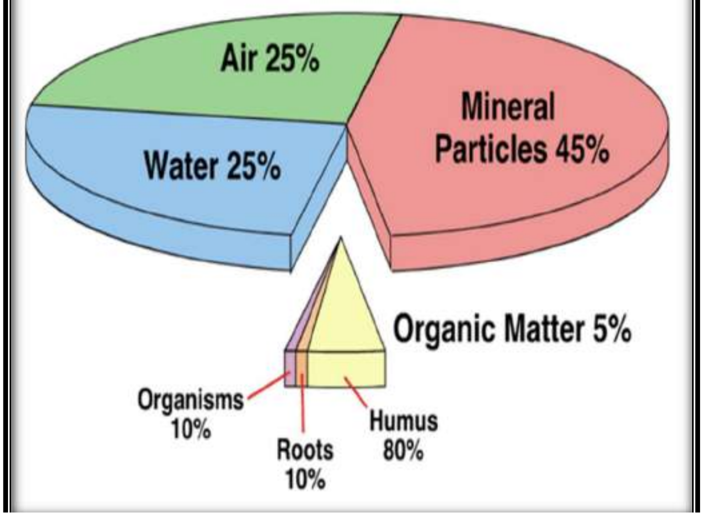
Essential Nutrients present in the soil

9. Most soils contain four basic components: mineral particles, water, air, and organic matter. Organic matter can be further sub-divided into humus, roots, and living organisms. **Figure 2.3** given below shows the basic composition of soil. Soils contain

several essential nutrients and fertility of a soil is a delicate balance of the physical, biological, and chemical properties. Therefore, initial step in maintaining healthy soil is knowing the quantity of each nutrient it contains, and how those nutrients behave in the soil.

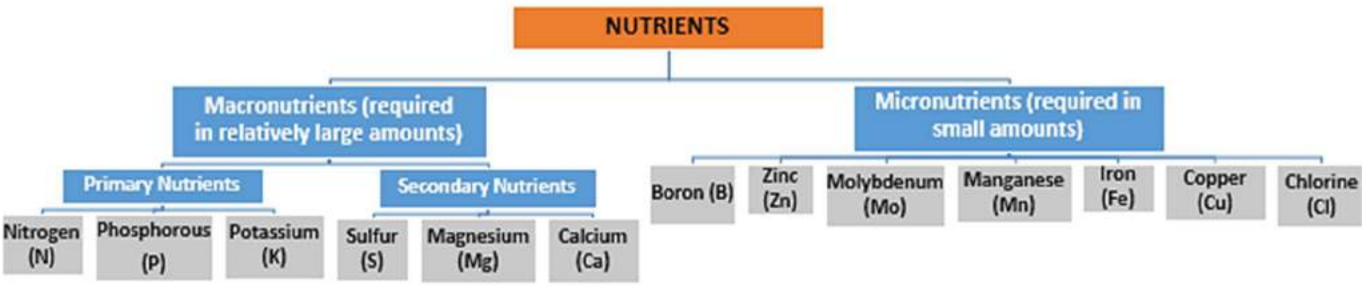
10. Water and air provide plants with three necessary nutrients: carbon, hydrogen, and oxygen. Soil nutrients are divided into two categories viz. Macro nutrients and Micro nutrients. Plants need more of the macro nutrients than micro nutrients. It is important to have a balance between the two because too few macronutrients can lead to poor plant growth and potential for disease and too many micronutrients can lead to loss of colour in the plant and reduced growth. Similarly, too few micronutrients will result in reduced flowering and yellow-green colouration. **Figure 2.4** given below shows the structure of several essential nutrients generally available in soil. Nutrient deficiency occurs when an essential nutrient is not available in sufficient quantity to meet the requirements of a growing plant. Toxicity occurs when a nutrient is in excess of plant needs and decreases plant growth or quality. **Appendix -I** shows the general functionality and their effects in case of excess and deficient concentration of several essential nutrients available in soil.

Figure 2.3. Basic components of soil



*Proportions of each vary in different soils, but these are proportions for a typical soil.
Source: http://www.physicalgeography.net/fundamentals/10t.html

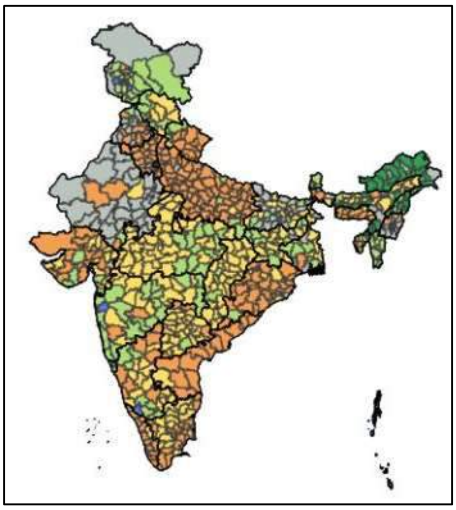
Figure 2.4. Nutrients available in soil



Government Programme on Soil Health – Soil Health Card

11. Soil health and quality remain a matter of great concern for the Government of India. Of the several programmes being run by the Government of India for monitoring soil health, some of them dating back to 1955-56, Soil Health Card (SHC) scheme is a flagship programme launched in February 2015, under which uniform norms are followed across different States for soil analysis for not just diagnosing fertility related constraints but also to make site specific fertilizer recommendations. The scheme is managed by Integrated Nutrient Management (INM) Division in the Ministry of Agriculture and Farmers Welfare, Government of India. Under this scheme, soil health condition is assessed w.r.t. 12 important soil parameters namely –

- (i) Nitrogen (N), Phosphorus (P), Potassium (K) - the macro-nutrients;
- (ii) Sulphur (S) – the secondary-nutrient;
- (iii) Zinc (Zn), Iron (Fe), Copper (Cu), Manganese (Mn), Boron (B) - micro-nutrients;
- (iv) pH, Electrical Conductivity (EC), Organic Carbon (OC) - physical parameters.



12. Soil samples collected from different locations are analysed in the Soil Testing Labs (STL) as per the norms provided in the scheme's operational guidelines. The results are uploaded in the national Soil Health Card portal www.soilhealth.dac.gov.in which has been developed for registration of soil samples, recording test results of soil samples and generation of Soil Health Cards (SHCs) along with fertilizer recommendations besides an information module for monitoring progress. The authorities provide a report to the farmers once in 3 years after observing the soil regularly. Examination of farmer's soil will help to decide upon the type of crops to be cultivated for more income. Professionals are also employed to help the farmers in adopting remedial measures.

13. During the 1st Cycle (2015-16 to 2016-17) 253.49 lakh soil samples were collected and 1073.89 lakh soil health cards were distributed to farmers and during the 2nd Cycle (2017-18 to 2018-19) as on 23.8.2019, 272.32 lakh soil samples have been collected and 1079.52 lakh soil health cards have been distributed to farmers.

Soil Nutrient Index

14. In order to compare the levels of soil fertility of one area with those of another it was necessary to obtain a single value for each nutrient. Nutrient index(N.I) value is a measure of nutrient supplying capacity of soil to plants (Singh et al., 2016)[6]. The nutrient index approach introduced by Parker et al.(1951)[7] has been adopted and modified by several researchers such as Shetty et al., (2008)[8]; Pathak, H. et al. (2010)[9], Sidharam, P. et al. (2017)[10], Chase, P., & Singh, O. P. (2014)[11], Amara, D. M. K. et al(2017)[12] and national /international organizations such as ICAR -NBSS&LUP[13], Ministry of Agriculture (Govt. of India)[14], FAO[15] etc. This index is used to evaluate the fertility status of soils based on the samples in each of the three classes, i.e., low, medium and high. The states/UT's wise nutrient index was evaluated for the soil samples analysed using the following formula:

Nutrient Index (N.I.) = $(N_L \times 1 + N_M \times 2 + N_H \times 3) / N_T$

where, N_L : Indicates number of samples falling in low class of nutrient status
N_M : Indicates number of samples falling in medium class of nutrient status
N_H : Indicates number of samples falling in high class of nutrient status
N_T : Indicates total number of samples analysed for a given area.

Interpretation of the different values of Soil Nutrient Index are given in **Table 2.1**.

Table 2.1: Rating Chart of Nutrient Index

S.No.	Nutrient Index	Value	Interpretation
1	Low	<1.67	Low fertility Status of the area
2	Medium	1.67-2.33	Medium fertility Status of the area
3	High	>2.33	High fertility Status of the area

[6] Singh, G., Sharma, M., Manan, J., & Singh, G. (2016). Assessment of soil fertility status under different cropping sequences in District Kapurthala. *J Krishi vigyan, 5(1), 1-9*.
[7] Parker, F. W., Nelson, W. L., Winters, E., & Miles, I. E. (1951). The broad interpretation and application of soil test information. *Agronomy Journal, 43(3), 105-112*.
[8] Vishwanath Shetty, Y., Nagamma, M. S., Dinesh Kumar, M., & Jayaprakash, S. M. (2008). Fertility status in arecanut garden soils of Karnataka. *Karnataka Journal of Agricultural Sciences, 21(4)*.
[9] Pathak, H. et al. (2010). Trend of fertility status of Indian soils. *Current Advances in Agricultural Sciences, 2(1), 10-12*.
[10] Sidharam, P., Kumar, K. S. A., & Srinivasamurthy, C. A. (2017). Soil fertility status and nutrient index for primary nutrients in Western Ghats and Coastal Karnataka under different agro-ecological systems. *Asian Journal of Soil Science*, 12(2), 314-319.
[11] Chase, P., & Singh, O. P. (2014). Soil nutrients and fertility in three traditional land use systems of Khonoma, Nagaland, India. *Resources and Environment*, 4(4), 181-189.
[12] Amara, D. M. K., Patil, P. L., Kamara, A. M., & Saidu, D. H. (2017). Assessment of soil fertility status using nutrient index approach. *Academia Journal of Agricultural Research*, 5(2), 28-38.
[13] http://14.139.123.73/bhoomigeoportal/publication_pdf/annual_report_publication/15_16.pdf
[14] http://www.agriculture.uk.gov.in/files/Soil_Testing_Method_by_Govt_of_India.pdf
[15] Soil and Plant Testing and Analysis, FAO Soils Bulletin 38/1 (http://www.fao.org/3/ar117e/ar117e.pdf)

15. In an effort to put together the existing status of macro and micro nutrients in different states/UT's and analyse the trend in fertility status of Indian soils, the information on the soil samples collected under Soil Health Card Scheme for cycle I (2015-16 to 2016-17) and cycle II (2017-18 to 2018-19) as on September 5, 2019 has been used. As per the data available for Cycle I & II at Soil Health Card website, status of Macro Nutrients has been categorized into five categories i.e. **Very low**, **Low**, **Medium**, **High**, **Very high** and status of Micro Nutrients has been categorized into two categories i.e. **Sufficient** & **Deficient**. For the sake of convenience, in case of Macro nutrients, "**Very low**" and "**Low**" category samples are taken under "**Low class of nutrient status**" and "**High**" and "V**ery high**" category samples are taken under "**High class of nutrient status**". Similarly, in case of Micro nutrients, "**Deficient**" category samples are taken under "**Low class of nutrient status**" and "**Sufficient**" category samples are taken under "**Medium class of nutrient status**".

Soil Nutrient Indices in States of India

16. The state-wise Soil Nutrient Index, by each of the macro and micro nutrient, for Cycle I and Cycle II is given in the **Statement 2.1 and 2.2**. A comparative statement of state-wise distribution of macro and micro nutrients indices is given in the **Table 2.2** below.

Table 2.2: State-wise Distribution of Soil Nutrient Indices - Macro and Micro Nutrients

S. No	STATES / UT's	CYCLE I (2015-2017)			CYCLE II (2017-2019)		
		LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
1	A & N Islands	N, P, K, OC, S	B, Cu, Fe, Mn, Zn		N, P, K, OC, S	B, Cu, Fe, Mn, Zn	
2	Andhra Pradesh	N, B, Fe, Zn	K, OC, Cu, Mn, S	P	N, Zn	OC, B, Cu, Fe, Mn, S	P, K
3	Arunachal Pradesh	P, B, Zn	K, Cu, Fe, Mn, S	N, OC	P, K, B, S, Zn	Cu, Fe, Mn	N, OC
4	Assam	P, K, B	N, OC, Cu, Fe, Mn, S, Zn		P, K, B	N, OC, Cu, Fe, Mn, S, Zn	
5	Bihar	N, B, Cu, S, Fe, Mn, Zn	P, K, OC		N, B, Fe	P, K, OC, Cu, Mn, S, Zn	
6	Chhattisgarh	N, B, Zn	P, K, OC, S, Cu, Fe, Mn,		N, S, Zn	P, K, OC, B, Cu, Fe, Mn	
7	D & N Nagar Haveli	N, P	OC, B, Cu, S, Fe, Mn, Zn	K	N, P	OC, B, Cu, S, Fe, Mn, Zn	K
8	Daman And Diu				N, P, B	K, OC, Cu, S, Fe, Mn, Zn	

S. No	STATES / UT's	CYCLE I (2015-2017)			CYCLE II (2017-2019)		
		LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
9	Delhi	N, P, OC, Fe, Mn	K, B, Cu, S, Zn		P	N, OC, B, Cu, Fe, Mn, S, Zn	K
10	Goa	P, B	N, K, Cu, Fe, Mn, S, Zn	OC	P, B, S	N, K, Cu, Fe, Mn, Zn	OC
11	Gujarat	N, B, Fe, S, Zn	P, K, OC, Cu, Mn		N, B	P, OC, Cu, Fe, Mn, S, Zn	K
12	Haryana	N, P, OC	K, B, Cu, Fe, Mn, S, Zn		N, P, OC, B, Fe, Mn	K, Cu, S, Zn	
13	Himachal Pradesh	N	P, K, B, Cu, Fe, Mn, S, Zn	OC	N	P, K, B, Cu, Fe, Mn, S, Zn	OC
14	Jammu And Kashmir	P, B, Fe, Mn, S, Zn	N, K, OC, Cu		P, Mn, S, Zn	N, K, B, Cu, Fe	OC
15	Jharkhand	N, P, B, S, Zn	K, OC, Cu, Fe, Mn		N, P	K, OC, B, Cu, Fe, Mn, S, Zn	
16	Karnataka	N, B, Fe, S, Zn	P, K, OC, Cu, Mn		N, B, Fe, S, Zn	P, K, OC, Cu, Mn	
17	Kerala	N, B, S	P, K, Cu, Fe, Mn, Zn	OC	N, B, S	P, K, Cu, Fe, Mn, Zn	OC
18	Madhya Pradesh	N, P, Zn	K, OC, B, Cu, Fe, Mn, S		N, P, Zn	K, OC, B, Cu, Fe, Mn, S	
19	Maharashtra	N, OC, B, Fe, S, Zn	P, Cu, Mn,	K,	N, B, Fe, S, Zn	P, OC, Cu, Mn	K
20	Manipur	N, P, K, Fe, Mn	OC, B, Cu, S, Zn		N, P, B, S, Zn	K, Cu, Fe, Mn	OC
21	Meghalaya	N, P, K, B, Fe, S	Cu, Mn, Zn	OC	N, P, K, Mn, S, Zn	B, Cu, Fe,	OC
22	Mizoram	P, OC, B	N, K, Cu, Fe, Mn, S, Zn		P, OC, Cu, Mn	N, K, B, Fe, S, Zn	
23	Nagaland	P, Cu, Zn	K, B, Fe, Mn, S	N, OC	P, Zn	K, B, Cu, Fe, Mn, S	N, OC
24	Odisha	N, P, OC, B, Cu, Fe, Mn, S, Zn	K		N, P, OC, B, Cu, Fe, Mn, S, Zn	K	
25	Puducherry	N, P, OC, B	K, Cu, Fe, Mn, S, Zn		N, P, B	K, Cu, Fe, Mn, S, Zn	OC
26	Punjab	N, P, OC, B, Mn	K, Cu, Fe, S, Zn		N, P, OC, B, Mn	K, Cu, Fe, S, Zn	
27	Rajasthan	N, OC, B, Fe, S, Zn	P, K, Cu, Mn		N, OC, B, Fe, Zn	P, K, Cu, Mn, S	
28	Sikkim	B, Mn	N, P, K, Cu, Fe, S, Zn	OC	N, B	P, K, Cu, Fe, Mn, S, Zn	OC

S. No	STATES / UT's	CYCLE I (2015-2017)			CYCLE II (2017-2019)		
		LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
29	Tamil Nadu	N, OC, B, Fe, S	P, K, Cu, Mn, Zn		N, OC, B, Fe, S	P, K, Cu, Mn, Zn	
30	Telangana	N, P, OC, B, Cu, Fe, Mn, S, Zn	K		N, OC, Fe, Zn	P, K, B, Cu, Mn, S	
31	Tripura	P, K, S	N, OC, B, Cu, Fe, Mn, Zn		N, K	P, OC, B, Cu, Fe, Mn, S, Zn	
32	Uttar Pradesh	N, P, OC, B, S	K, Cu, Fe, Mn, Zn		N, P, OC, B, S	K, Cu, Fe, Mn, Zn	
33	Uttarakhand	N, B	P, K, OC, Cu, Fe, Mn, S, Zn		N, B	P, K, OC, Cu, Fe, Mn, S, Zn	
34	West Bengal	N, B, S, Zn	K, OC, Cu, Fe, Mn	P	S	N, K, B, Cu, Fe, Mn, Zn	P, OC

Nutrients *- N: Nitrogen; P: Phosphorus; K: Potassium; S: Sulphur; Zn: Zinc; Fe: Iron; Cu: Copper; Mn: Manganese, B: Boron; OC: Organic Carbon.*

Level of Nutrients*: Low: <1.67; Medium: 1.67-2.33; High: >2.33*

17. Some inferences that can be made from these indices are:

i. ***Nitrogen*** fertility status in both cycles has been generally low, except in the case of Arunachal Pradesh and Nagaland.

ii. ***Phosphorus*** fertility status has either been low or medium in majority of States for both cycles.

iii. ***Potassium*** fertility status has been medium in most of the States for both cycles.

iv. Even during this short period between the two cycles, the status of some soil nutrients from Cycle I to Cycle II has become better in the States of Andhra Pradesh, Bihar, Delhi, Gujarat, Jharkhand, Manipur, Telangana and West Bengal. However, for many of the other States like Assam, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Odisha, Punjab, Tamil Nadu, Uttar Pradesh and Uttarakhand, there is no major change in the status of nutrients.

18. Maps on the fertility status in respect of the macro-nutrients - Nitrogen, Phosphorus and Potassium – are given in **Figure 2.5**.

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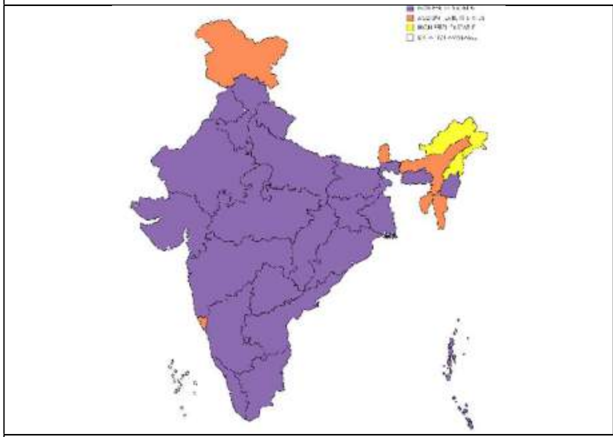
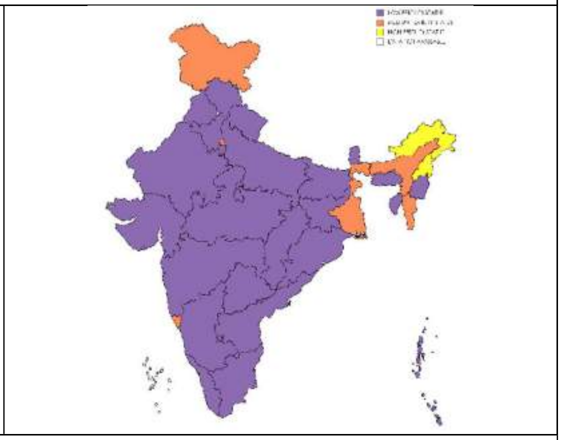
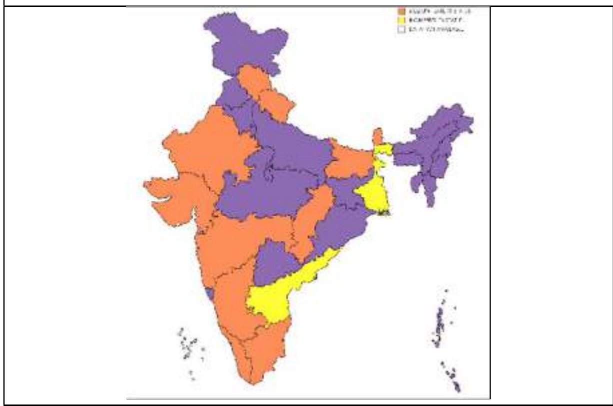
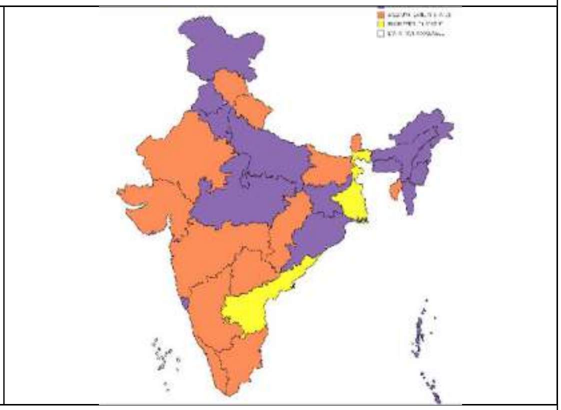
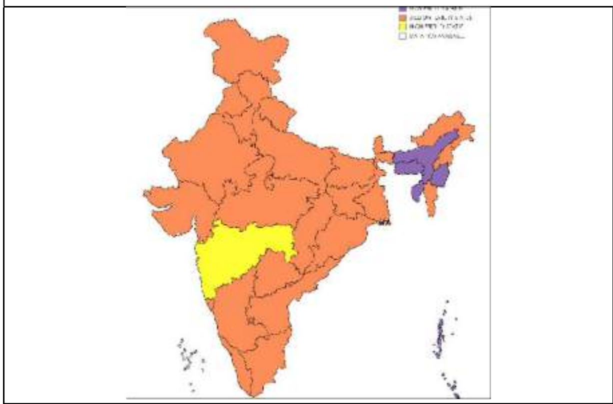
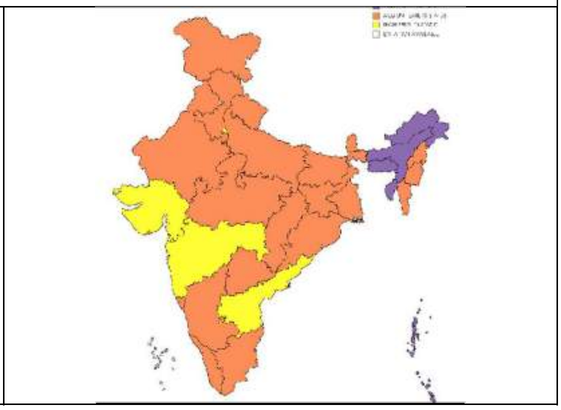
Figure 2.5. Status of macro-nutrients, Cycle I and Cycle II

Cycle I : 2015-2017	Cycle II : 2017-2019
NITROGEN FERTILITY STATUS	
	
PHOSPHORUS FERTILITY STATUS	
	
POTASSIUM FERTILITY STATUS	
	

Rating Chart of Nutrient Index			
Legend	**Nutrient Index**	**Value**	**Interpretation**
(purple)	Low	<1.67	Low fertility status of the area
(orange)	Medium	1.67-2.33	Medium fertility status of the area
(yellow)	High	>2.33	High fertility status of the area

Water Quality Accounts

Chapter 3

Water Quality Accounts

"Filthy water cannot be washed."

African Proverb

Introduction

Water is essential for the sustenance of human life and the economy. In context of a typical ecosystem, water has a dual role – it is not only a service from ecosystems but also a rich ecosystem in itself (MA 2005)[16]. Water is also closely related to socio-economic development. Water has cross sectoral linkages with various sectors such as food, energy, agriculture, industries and urban development and others, thus, cannot be considered in isolation, making it challenging for the policy makers to apportion diminishing supplies between ever-increasing demands. Factors such as demography and climate change further increase the stress on water resource and highlighting the need for water security **(Figure 3.1).** In many regions, the availability of water in both quantity and quality is being severely affected by climate variability and climate change, with more or less precipitation in different regions and more extreme weather events. Thus, water resource management plays an important role. Integrated Water Resource Management (IWRM)[17] is a process that promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. IWRM is not an end but a means of achieving sustainable management of water resources, not just for the quantity but for the quality as well. Its relevance is depicted from the fact that Target 6.5 of Sustainable Development Goal (SDG) i.e. "By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate" and especially Indicator 6.5.1, which indicates the degree of integrated water resources management implementation (0 – 100), are dedicated to water resources management.

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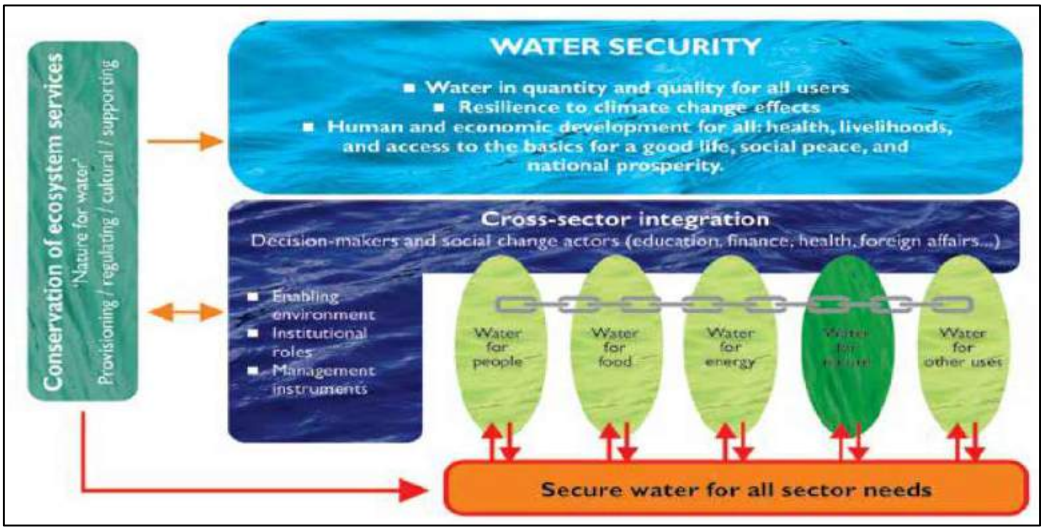
[16] MA (Millennium Ecosystem Assessment). 2005. Ecosystems and Human Well Being: findings from responses, Chapter 7: Freshwater, Working Group. Washington, DC: Island Press

[17] TAC, GWP (2000), "Integrated Water Resources Management", TAC Background Paper No. 4, Global Water Partnership, Stockholm

Figure 3.1: Water quality and the conservation of ecosystem services and its relation to Integrated Water Resource Management (IWRM)[18]



2. Water is an indispensable element in every sector of the economy, be it primary, secondary or tertiary sectors. These water demands are fulfilled by various sources of water supply - surface water bodies like river, lakes and ponds; groundwater and others. But these resources are under severe environmental stress due to the growing population and increased levels of developmental activities, industrialization and urbanisation. Added to this is an increase in disposal of solid waste from urban and industrial hubs which has posed a threat for environment due to haphazard discharges into natural water sources and indiscriminate dumping in the agricultural fields. All these have resulted in water quality degradation despite the development of water resources with space and time.

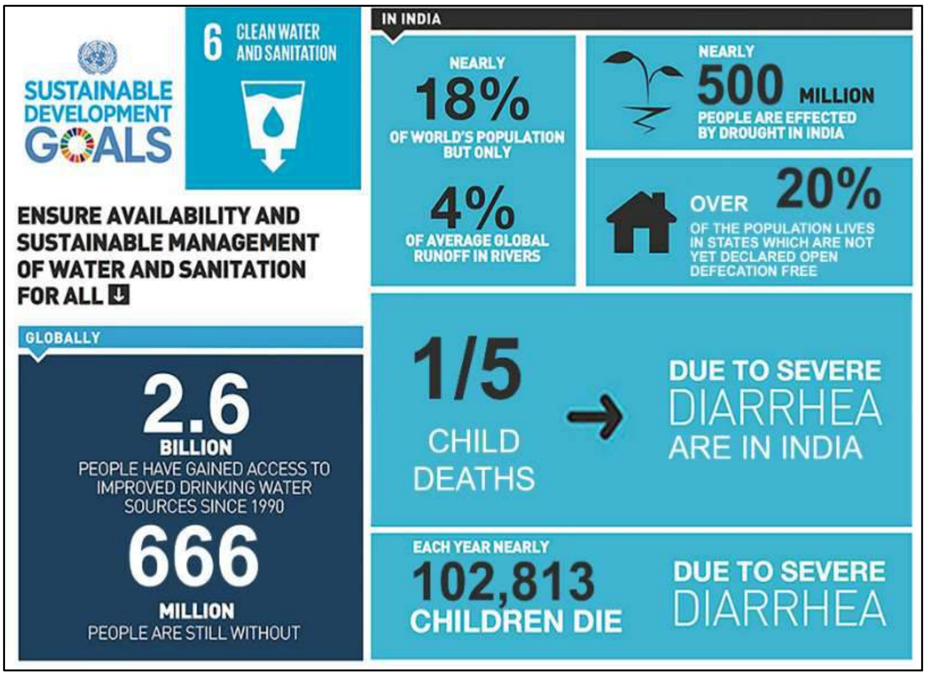
3. Any change in physical, chemical and biological properties of water that has a negative effect on its suitability for various uses is referred to as *water pollution*. The quality of water is under threat from industrial, agricultural, and domestic waste, and these contaminants become concentrated in water bodies by over-extraction. They also affect the quality when these pollutants interact with each other or decompose to produce toxic by-products. These pollutants are directly detrimental to human health when consumed in drinking water. For instance, water contaminated with heavy metals like arsenic, lead and cadmium has been associated with skin cancer, anaemia, headache, suppression of immune system, softening of the bones and kidney failure. Further, dumping of sewage into water bodies directly results in accumulation of toxic substances and depletion of

[18] Global Water Partnership (GWP) (2014) *Ecosystem Services and Water Security*. Briefing Note. GWP, Stockholm, Sweden can be accessed at https://www.gwp.org/globalassets/global/toolbox/publications/perspective-papers/gwp_pp_-ecosystemservices.pdf

oxygen which not only affects the water quality but also affects the aquatic life and the food chain of birds and animals.

4. Clean water is critical to survival, and its absence can impact the health, food security, and livelihoods of families across the world. As depicted in the **Figure 3.2**[18] below, one-fifth of the child deaths in India are due to Diarrhoea, although overall proportion of Indian households with access to improved water sources increased from 68% in 1992-93 to 89.9% in 2015-16, but still there is a need of significant improvement. In this regard, Government of India has introduced some flagship programmes namely, Swachh Bharat Abhiyan to clean India, the National Rural Drinking Water Programme, and Namami Gange, which aims at the conservation of the River Ganga.

Figure 3.2: SDG 6 and India[19]



5. The importance of water quality is illustrated through the fact that Sustainable Development Goal 6 is dedicated to Clean Water and Sanitation, especially, Target 6.3 aims to improve ambient water quality, which is vital to protect both ecosystem health and human health, by eliminating, minimizing and significantly reducing different streams of pollution into water bodies. Also, the associated indicator 6.3.2 reflects the proportion of bodies of water with good ambient water quality. "Good" indicates an ambient water quality that does not damage ecosystem function and human health according to core ambient water quality parameters.

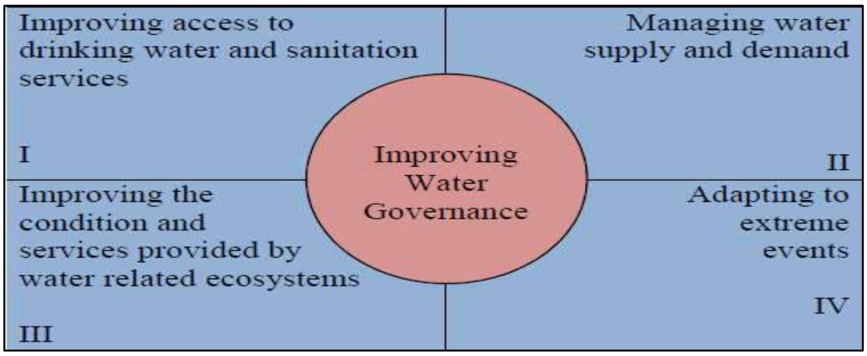
[19] https://in.one.un.org/page/sustainable-development-goals/sdg-6/

6. Water quality can be assessed using physical, chemical and biological parameters. Water can be harmful for health, when the values of these parameters are outside the defined limits. Water Quality Accounts are one of the most effective ways to describe the quality of water and to assist in the formulation of appropriate policies by various environmental agencies. In general, water quality can be assessed on the basis of (actual or desired) water uses/ functions or against general standards.

Importance of Water Quality Accounts

7. Water quality accounts can provide a valuable support to policy making because they can help set standards and objectives, check compliance and assess the efficacy of policy measures. The water quality accounts also allow for comparability across water bodies by providing information on trends across time. It can also be used in assessments of the impacts of pollution and can help evaluate the policies aimed at decreasing pollution or improving the state of water bodies. Thus, water accounts can assist in a wide range of analytical and policy situations. United Nations World Water Assessment Programme (UNWWAP) and UNSD (2011)[20] grouped the water policy objectives into four broad categories providing a base for improved water governance (**Figure 3.3**).

Figure 3.3: Water Policy Objectives[21]



8. In many cases, human activities and natural phenomena interact in such a way making it impossible to establish a clear and linear relationship between the economy and water quality. For example, the change in the concentration of nitrates and phosphates in a water body can be associated with the use of fertilisers in nearby agricultural areas. Changes in water quality may depend not only on changes in the discharge of pollutants but also on natural processes (like ecosystem functions and hydrological dynamics), change in dilution levels due to variations in levels of abstraction or precipitation and combined effects with other pollutants. As a result, water quality accounts if combined

[20] "Monitoring Framework for Water", UNWWAP and UNSD (2011)

[21] Vardon, M. "Water and ecosystem accounting", *Supporting document to the Advancing the SEEA Experimental Ecosystem Accounting project, United Nations* (2014), can be accessed at https://seea.un.org/sites/seea.un.org/files/anca-tech-guid-4.pdf

with information on economic activities may also provide insights on the role of the different sectors in determining water quality.

9. Water Quality Accounts can also help evolve Water Quality Indices (WQI), which provide tangible information about water purity and facilitates a better system for quality monitoring. Importance of WQI can be highlighted from its various uses[22]:

- ***Resource allocation-*** Indices may be applied in water-related decisions to assist managers in allocating funds and determining priorities,
- ***Ranking*** of the location by comparing the environmental conditions at different locations or geographical areas,
- ***Standard enforcement-*** Indices can be used at specific locations to determine the extent to which legislative standards and existing criteria are being met or exceeded,
- ***Trend analysis-*** Indices can also be applied to environmental data at different locations in time to determine the changes in environmental quality which have occurred over a period,
- ***Public information-*** Indices can also be used to inform the public about the environmental conditions,
- ***Scientific research-*** Indices may be applied as means for reducing large quantity of data to a form that gives insight to the research and conducting study of some environmental programs.

10. Just like any other index, WQI has the capability to reduce the bulk information into a single value to express the data in a simplified and logical form. It takes information from a number of sources and combines them to indicate the overall status of a water system at a certain location and time. It also allows for comparisons to be made between different rivers. They aid in highlighting the water quality issues for the policy makers as well as for the general public and users of the water resources and also in assessing the suitability of river waters for a variety of uses such as agriculture, aquaculture and domestic use. Water resources being an important environmental asset, their condition or quality are a crucial input in environmental accounting.

Parameter Trade-off

11. Contaminants can be classified into different categories including organic, inorganic, biological and thermal. It would clearly be unfeasible to monitor every compound that is discharged into water supplies; instead a number of indicator criteria are used. Different countries tend to use different indicators, based on their specific

[22] http://shodhganga.inflibnet.ac.in/bitstream/10603/53841/11/11_chapter%204.pdf

problems and needs. Hence, there is a trade-off between comparability across river basins and countries and level of detail of the analysis. Moreover, if the objective of water quality accounts is to have standardised and widely used indicators, then only a low level of detail and focus on local, specific problems can be expected. The parameters that affect the quality of water depends on the nature of industries present, locality of the river i.e. the nature of pollutants differ across states, and different states have different types of problems; for example[23], Punjab faces the presence of lead in its water while Madhya Pradesh shows presence of manganese, and Karnataka is struggling with the presence of zinc. So when focussing on the national level, a trade-off would need to be made between the intricate detail at local level and the nation-wide acceptable parameters.

12. As the water quality accounts must be comparable throughout the country, only a limited number of criteria used in every state can be included in this study. The data needs to be consistent not only spatially but also temporally, further constraining the number of parameters available for use.

Importance of Parameters

13. There are many compounds used in agriculture, at home, in industries and in solid wastes which can find their way into surface water and groundwater, affecting their quality. The effect of these substances depends on the quantity of water consumed per day and their concentration in water. Normally, the concentration of most potentially harmful impurities in natural waters is very low but still in the case of humans, this contamination can transmit into a wide variety of diseases and illness. Similarly, the quality of irrigation water for agricultural use should be such that it does not impair plant growth or adversely affect the productivity of the land. Thus, parameters are selected to monitor water quality across the country based on their importance and their effects in various uses. The impact of some of the parameters used for assessing water quality on human health, livestock, irrigation water and industries is given in **Appendix-II**.

Compilation of Water Quality Accounts

14. The complexity exists in inferring the status of water quality from the data available from different monitoring sites, thus, highlighting the need to specify the water quality status using indicators that are easier to interpret. SEEA-Water[24] describes methodology

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[23] Kumar, P., Sanyal, S., Sinha, R., & Sukhdev, P. (2007). Accounting for freshwater quality in India. *Green Accounting for Indian States Project, Monograph, 8*.

[24] United Nations Statistics Division (2012) System of Environmental-Economic Accounting for Water (SEEA-Water). Department of Economic and Social Affairs. Statistics Division. ST/ESA/STAT/SER.F/100; http://unstats.un.org/unsd/envaccounting/seeaw/seeawaterwebversion.pdf

to assess the water quality through Water Quality Accounts since quality is an important characteristic of water and can limit its use. Quality Accounts describe the quality of the stocks of water resources and water quality is reported in the form of discrete classes. It is not possible to distinguish changes in quality due to human activities from changes in quality due to natural causes. The quality of a body of water may be approached in terms of its uses/functions or its condition in the natural form, and different countries use different classification, although there is no standard classification of water uses/functions.

15. Fundamental issue when discussing quality is whether quality determines use, or use determines quality. In the latter case, for each such body, a specific use or uses are identified and the quality criteria are set accordingly. The standards are specific for the body of water. In the case of multiple uses, water quality could be defined in terms of its most sensitive or stringent use. Most countries however, follow the "quality determines use" perspective, and often quality is assessed with respect to some thresholds. These thresholds are based on either natural (or background concentrations), or on legal requirements (i.e. prescriptive standards).

16. Considering the importance of water quality, Inter-Ministerial Group (IMG) on Environmental Economic Accounting in India constituted a "Sub-Group on the compilation of indices relating to water quality" under the Chairpersonship of Additional Secretary, Department of Water Resources, River Development & Ganga Rejuvenation, Ministry of Jal Shakti with the experts from Central Water Commission (CWC), Central Ground Water Board (CGWB), Central Pollution Control Board (CPCB), National Centre for Coastal Research (NCCR) and Ministry of Environment, Forests and Climate Change (MoEF&CC), to work out the methodology for development of WQI for surface/ground/marine water along with parameters, their weights and standards/permissible limits. It was envisaged that these indices/accounts will provide the linkage between environment and economy, enable assessment of the disservices done by the economy to environment in terms of degradation and also help in identifying the areas warranting focused interventions for taking remedial measures and evaluation. In addition, it was also envisaged that these accounts/indices will also help in aggregating the detailed statistics on water quality being released by the concerned agencies in a manner to reflect the direction of combined fluctuations in the different variables / monitoring stations.

17. Based on the discussions in the Sub-Group, methodology as recommended by SEEA-Water has been adapted to compile water quality accounts based on designated best use quality classes for surface and groundwater. The limits for various water quality

parameters for these designated best use quality classes for surface and groundwater, as suggested by Sub-Group, is given at **Appendix-III and Appendix-IV**. In short, the quality classes have been categorized in accordance to the uses for which the water is fit for. The "designated best use classes of water" as used in the water accounts are mentioned below in **Table 3.1**.

Table 3.1: Designated best use classes of water

Quality Classes for Surface Water	Quality Classes for Groundwater
Class A: **Drinking Water Source without conventional treatment but after disinfection** ***Class B:*** **Outdoor bathing (Organised)** ***Class C:*** **Drinking Water Source after conventional treatment and disinfection** ***Class D:*** **Propagation of Wildlife and Fisheries** ***Class E:*** **Irrigation, Industrial Cooling, Controlled Waste Disposal** ***Class U:*** **Unclassified-Not classified as 'A' to 'E' or inadequate information**	***Class A:*** **Drinking Water Source – Class I** ***Class C:*** **Drinking Water Source – Class II** ***Class E:*** **Irrigation** ***Class U:*** **Unclassified-Not classified as 'A' to 'E' or inadequate information**

18. The major usage of groundwater is for irrigation, drinking and domestic uses and hence, there is a slight variation across surface and groundwater, in the way the quality classes are defined as shown in the above table. Also, the category "Unclassified" refers to any measurement point where the parameters do not fulfil criteria for quality classes "A" to "E" or the information is insufficient to classify the data point under any of the specified quality classes. The structure of Quality Accounts for surface and groundwater, as evolved during the discussions of the Sub-Group, for a given geographic area is shown below in **Table 3.2 and 3.3.**

Table 3.2: Quality Accounts (Physical units) for Surface Water

Year1	Quality Class					
	A	B	C	D	E	U
Monitoring Site 1						
Month1						

Year1	Quality Class					
	A	B	C	D	E	U
Month2						
…..						
Monitoring Site 2						
Month1						
Month2						
….						

Table 3.3: Quality Accounts (Physical Units) for Groundwater

Year 1	Quality Class				
	A	C	E	U	Total
Stock at State					
District 1					
District 2					
and so on					
………					

19. Each entry in the table represents the amount of water of a certain quality measured in the volume of the water. In the case of rivers, owing to the flowing nature of the water, the volume of the river is approximated by a specific unit of account, the "standard river unit" (SRU). The value, in Standard River Units (SRU), of a stretch of river of length L and of flow q is the product of L multiplied by q. Quality accounts for rivers can be compiled by assessing the quality class for each stretch, by computing the SRU value for each stretch, and by summing the corresponding SRU per quality class to populate the quality accounts. The different quality classes can then be aggregated without double counting. It may be noted that volume corresponding to stretches of river water where the river bed is dry and does not allow for collection of sample will be 'zero'.

20. In the case of rivers, monitoring station-wise data is given. The water of each monitoring station shall be allocated to a unique quality class as per the recorded values of the different quality parameters and the threshold values given in **Appendix-III**. An essential utility of the water quality accounts is to help combine the numerous water quality indicators into a single value for a given time period. For this, use of Standard River Units has been recommended by the SEEA-Water manual for rivers. The Standard

River Units (SRU), which are indicative of the volume of water, can be derived using the length and discharge values. Assuming that the stretch between two monitoring stations is uniform in quality and flow, the standard river units can be allocated to the corresponding quality-class. The comparison of changes in "stocks of quality" is expected to provide an assessment of the effectiveness of protective and restorative measures.

21. Similarly, in case of groundwater, the data is given location-wise which is classified into the corresponding "designated best use classes of water" based on the threshold values as mentioned in the **Appendix-IV,** as specified as in Bureau of Indian Standards [IS 10500: 2012 (Second Revision) and IS 11624 (1986, Reaffirmed 2009)] and some modifications suggested by Central Ground Water Board (CGWB). Certain parameters could not be considered due to non-availability of information. In respect of the volume, the SRU's are replaced by Net Annual Groundwater Resources which are available block-wise, and are assumed to be equally distributed across locations within the block. Thus, quality accounts for groundwater can be compiled by assessing the quality class for each location, by aggregating the Net Annual Groundwater Resources for the different monitoring locations as per the corresponding quality classes.

22. The proposed methodology can also be applied for other water bodies, like lakes and canals, albeit with certain modifications. A major advantage of this quality account is the capacity to depict the changes in quality over the different months as also across the different stretches of water. For the ease of comprehension, these could also be depicted as maps to identify seasonal changes of water quality. Further, since the monitoring stations can be uniquely attributed to a state, state-wise quality accounts can also be compiled easily, if required.

Accounts for Surface Water – Case of Godavari River Basin during 2015-16

23. The Godavari is the third largest basin and accounts of nearly 9.5% of the total geographical area of India. It extends over states of Maharashtra (48.6%), Andhra Pradesh, Telangana (23.4%), Chhattisgarh (10.9%), and Odisha (5.7%) in addition to smaller parts in Madhya Pradesh (10.0%), Karnataka (1.4%), and Union territory of Puducherry (0.01%). The core components of the water network include the river Godavari, the largest of the peninsular river and its principal tributaries finally draining into the Bay of Bengal. The river Godavari rises at an elevation of 1067 m in the Western Ghats near the Triambak hills in the Nasik district of Maharashtra. The Godavari receives the waters from the Darna, the Pravara and the Manjra on its right bank whereas from the Kadwa, the Purna, the Pranhita,

the Indravati and the Sabari on its left bank. The Godavari basin receives major part of rainfall during the south-west monsoon season (months). The delta of the Godavari gradually extends into the sea and consists of a wide belt of river borne alluvium.

24. The Water Quality Accounts have been compiled for Godavari River Basin for the year 2015-16 with 12 data points, one for each month, using the data on quality parameters as furnished by Central Water Commission (CWC) for 26 monitoring stations across the basin. The detailed site-wise, month-wise quality accounts of Godavari River Basin for the year 2015-16 is given in the **Statement 3.1**. The percentage distribution of summary of site-wise and month-wise quality accounts of Godavari River Basin are given in the **Table 3.4** and **Table 3.5** below. A map depicting the month-wise changes in water quality across the basin is give in **Figure 3.4** at the end of the chapter.

Table 3.4: Site-wise Distribution of Water Quality in Godavari River Basin, 2015-16

(In %)

Sites	Designated Best Use Class					Grand Total	Share in total volume
	B	C	D	E	U		
Ashti	6.25	0.22	92.85		0.69	100	5.95
Bamni	17.90	3.13	75.06	2.49	1.42	100	2.73
Bhadrachalam			1.90	97.55	0.55	100	13.34
Bhatpalli	50.53		38.85		10.62	100	0.08
Hivra	38.42		28.40		33.18	100	0.42
Jagdalpur				100		100	2.63
Keolori	20.13	3.78	76.08			100	0.27
Konta		2.94	15.37	77.92	3.77	100	5.02
Kopergaon				100		100	5.32
Kumhari	17.44		82.56			100	0.79
Mancherial				79.54	20.46	100	1.13
Nandgaon	2.62		20.21	77.17		100	0.76
Nowrangpur			5.08	93.50	1.42	100	0.25
P.G.Bridge	32.09	0.13	11.29		56.49	100	0.32
Pachegaon				100		100	0.46
Pathagudem		0.12	0.12	99.01	0.75	100	3.98
Pauni	12.54		87.46			100	0.55
Perur			2.12	97.24	0.64	100	22.71
Polavaram			2.11	94.61	3.27	100	20.33
Rajegaon	9.95		90.05			100	1.18

Sites	Designated Best Use Class					Grand Total	Share in total volume
	B	C	D	E	U		
Ramakona	4.05	0.29	95.65			100	0.21
Sakmur	35.10		61.42		3.47	100	1.49
Sangam			2.71	97.01	0.28	100	0.15
Satrapur	6.69		83.57		9.74	100	0.20
Tekra	45.36		54.02		0.62	100	9.64
Wairagarh	5.89		94.11			100	0.11
Grand Total	6.48	0.26	18.86	72.53	1.87	100	100

Table 3.5: Month-wise Distribution of Water Quality in Godavari River Basin, 2015-16

(In %)

Godavari Basin	Designated Based Use Class					Grand Total
	B	C	D	E	U	
June	1.05			62.25	36.70	100.00
July	21.75		3.51	74.24	0.50	100.00
August	10.44		11.57	77.99		100.00
September			25.23	74.77		100.00
October	7.36		10.90	81.73		100.00
November	15.32		5.07	77.55	2.07	100.00
December	18.74		46.04	35.22		100.00
January	17.65	9.68	39.44		33.23	100.00
February	16.58		15.82		67.61	100.00
March	9.13		76.44	7.54	6.89	100.00
April	13.64	35.51	2.96		47.89	100.00
May	5.90		91.15	1.10	1.85	100.00
Total	**6.48**	**0.26**	**18.86**	**72.53**	**1.87**	**100.00**

25. Some findings from the quality accounts of Godavari River Basin during 2015-16 are:

- No stretch of water under Godavari River Basin was found to be of Class A. Further, only about 0.3% of water was found to be of Class C, i.e., water that could be used for drinking after treatment and disinfection.
- 73% of water of the Godavari Basin falls under the "**Class E: Irrigation, Industrial Cooling, Controlled Waste Disposal**" followed by 19% of water that falls under the "**Class D: Propagation of Wildlife and Fisheries**".

- More than 90% of water is suitable only for "**Class E: Irrigation, Industrial Cooling, Controlled Waste Disposal**" in several monitoring sites - Bhadrachalam, Jagdalpur, Kopergoan, Nowrangpur, Pachegaon, Pathagudem, Perur, Polavaram and Sangam.
- More than 80% of water of monitoring sites namely Asthi, Kumhari, Pauni, Rajegaon, Ramakona, Satrapur and Wairagarh is not fit for human use, but could be used for "**Propagation of Wildlife and Fisheries**".
- During the months of July to November 2015, more than 70% of water of Godavari Basin falls under the "**Class E: Irrigation, Industrial Cooling, Controlled Waste Disposal**".

Accounts for Groundwater – Case of Punjab and Haryana States during 2015

26. The States of Punjab and Haryana have been at the forefront in achieving national food security and adopting intensive agricultural practices since the green revolution. The intense agricultural activity has prompted usage of large quantity of fertilizers and pesticides for better crop yield. An undesirable side-effect of this has been the pollution of ground and surface water over space and time. Serious concern about deterioration of water quality in different parts of these States have been expressed at various levels. Therefore, the States of Punjab and Haryana have been considered for preparation of Groundwater Quality Accounts.

Punjab

27. The groundwater quality accounts for the state of Punjab for the year 2015 have been compiled based on the data on groundwater quality parameters provided by Central Ground Water Board for 291 sites across 119 blocks in 22 districts of the State, along with data on block-wise Net Annual Groundwater Resources for the year 2013.

28. The quality accounts, district-wise and block-wise, for the year 2015 are given in the **Statement No. 3.2,** depiction of which can be seen in **Figure 3.5** at the end of the chapter. **Table 3.6** gives the percentage distribution of quality of water across districts of Punjab.

Table 3.6: Distribution of groundwater quality in Districts of Punjab

(In %)

Districts	A	C	E	U	Grand Total
Amritsar		29.40	52.47	18.13	100.00
Barnala		0.00	12.03	87.97	100.00
Bathinda		3.27	46.38	50.35	100.00
Faridkot		3.76	20.48	75.76	100.00

Districts	A	C	E	U	Grand Total
Fatehgarh Sahib		0.00	80.31	19.69	100.00
Fazilka		14.33	39.51	46.16	100.00
Firozpur		0.00	34.41	65.59	100.00
Gurdaspur	4.08	29.21	66.71	0.00	100.00
Hoshiarpur	31.34	9.40	59.26	0.00	100.00
Jalandhar	8.77	20.49	45.92	24.83	100.00
Kapurthala	30.24	0.00	47.85	21.91	100.00
Ludhiana	9.04	12.64	48.27	30.05	100.00
Mansa		0.00	77.46	22.54	100.00
Moga		22.57	24.71	52.72	100.00
Muktsar		13.57	57.29	29.14	100.00
Nawanshahr	27.93	30.65	41.42	0.00	100.00
Pathankot	4.55	13.71	81.75	0.00	100.00
Patiala		6.98	49.41	43.62	100.00
Ropar	22.55	9.08	61.25	7.12	100.00
Sangrur		1.67	53.33	45.00	100.00
Sas Nagar		18.71	43.88	37.42	100.00
Tarn Taran		37.53	23.85	38.63	100.00
Grand Total	**5.08**	**13.96**	**47.32**	**33.64**	**100.00**

29. Some findings from the of groundwater quality accounts of Punjab for the year 2015 are:

- At state level, 47% of groundwater in the State of Punjab is only fit for irrigation.
- 33% of States' resources could not be classified specifically into Class A to Class E, meaning thereby that the resources cannot be used even for irrigation.
- In the districts of Barnala, Fatehgarh Sahib, Firozpur and Mansa, no samples of groundwater could be classified under the two classes of drinking water.
- Some samples of Class A of drinking water could be detected in only 8 of the 22 districts, viz. Gurdaspur, Hoshiarpur, Jalandhar, Kapurthala, Ludhiana, Nawanshahr, Pathankot and Ropar.

Haryana

30. The groundwater quality accounts for the state of Haryana for the year 2015 have been compiled based on the data on groundwater quality parameters provided by Central Ground Water Board for 352 sites across 97 blocks in 21 districts of the State, along with data on block-wise Net Annual Groundwater Resources for the year 2013. The quality

accounts, district-wise and block-wise, for the year 2015 are given in the **Statement No. 3.3,** depiction of which can be seen in **Figure 3.6** at the end of the chapter**. Table 3.7** gives the percentage distribution of quality of water across districts of Haryana.

Table 3.7: Distribution of groundwater quality in Districts of Haryana

(In %)

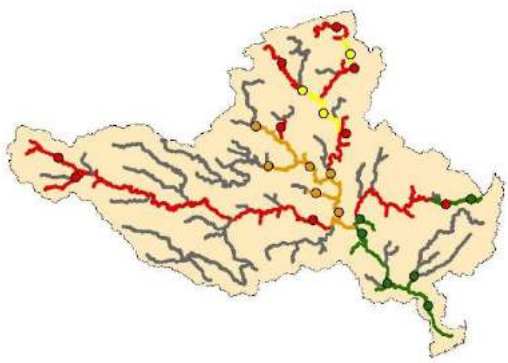
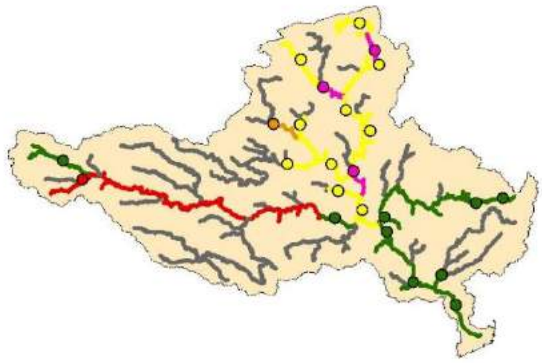
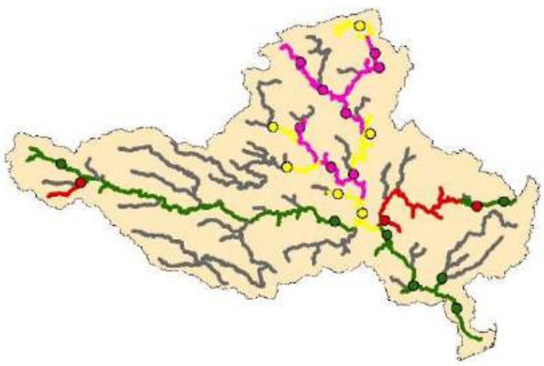
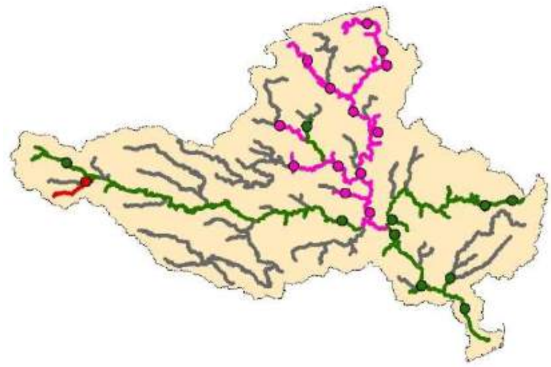
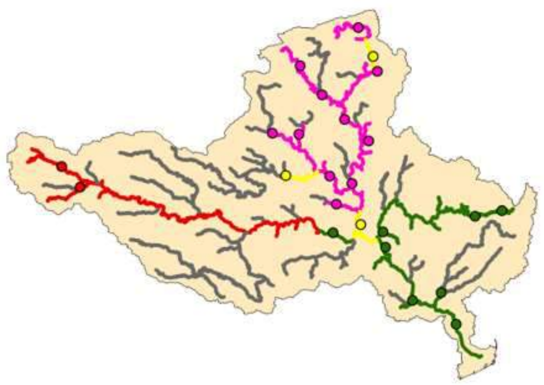
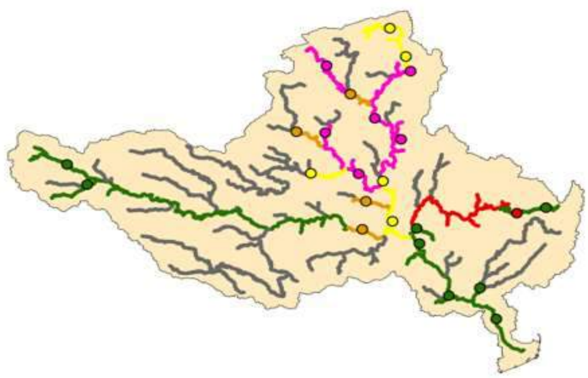
Districts	A	C	E	U	Grand Total
Ambala		3.92	18.68	77.39	100.00
Bhiwani		11.15	51.79	37.06	100.00
Faridabad		9.13	36.30	54.57	100.00
Fatehabad			64.52	35.48	100.00
Gurgaon	22.27	9.41	27.47	40.85	100.00
Hissar	5.72	2.87	64.00	27.41	100.00
Jhajjar	15.90		38.06	46.04	100.00
Jind		16.38	18.78	64.84	100.00
Kaithal		6.33	16.29	77.38	100.00
Karnal	4.20	12.76	34.41	48.62	100.00
Kurukshetra	17.21	37.96	32.24	12.60	100.00
Mahendergarh		24.47	3.92	71.61	100.00
Mewat	16.45		19.27	64.27	100.00
Palwal	5.98	8.84	31.20	53.98	100.00
Panchkula	22.27	14.66	37.79	25.28	100.00
Panipat		5.37	67.73	26.90	100.00
Rewari			33.89	66.11	100.00
Rohtak		19.69	35.74	44.57	100.00
Sirsa	10.64	5.65	21.06	62.65	100.00
Sonipat	1.12	12.34	29.08	57.46	100.00
Yamunanagar	17.66		74.43	7.91	100.00
Grand Total	5.27	10.26	36.11	48.35	100.00

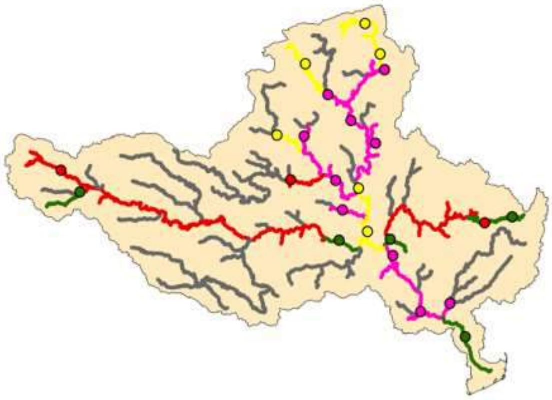
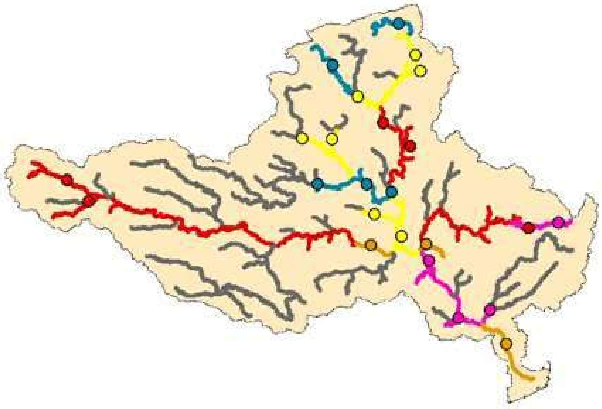
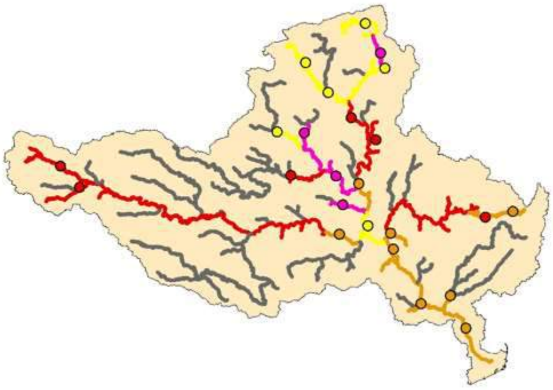
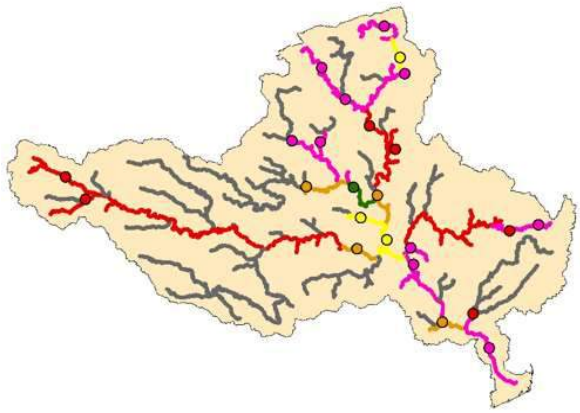
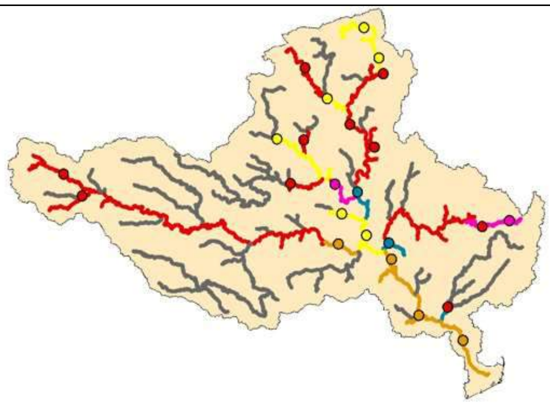
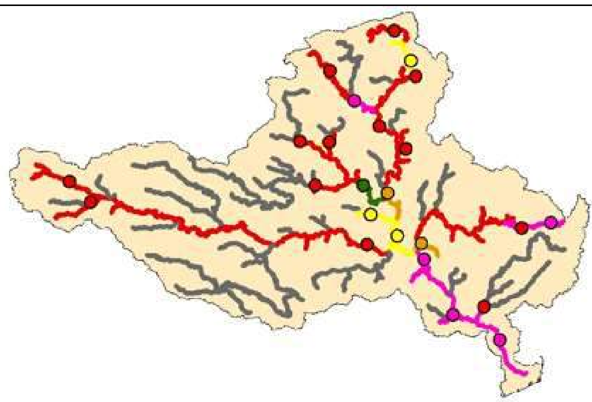
31. Some findings of groundwater quality accounts of Haryana for the year 2015 are:

- At state level, 36% of groundwater in the State of Haryana conforms to "**Class E: Irrigation Water"**.
- 48% of groundwater could not be classified into Class A to Class E, meaning thereby that this portion of the groundwater cannot be used even for irrigation.

- In the districts of Fatehabad and Rewari, no samples of groundwater could be classified under the two classes of drinking water. On the other hand, Panchkula and Kurukshetra had a significant, if not major, share of these two classes.
- Some samples of Class A of drinking water were detected in 11 of the 21 districts of the State.

Figure 3.4: Water Quality of Godavari River Basin, 2015-16

June 2015	July 2015
	
August 2015	**September 2015**
	
October 2015	**November 2015**
	

December 2015	January 2016
	
February 2016	March 2016
	
April 2016	May 2016
	

- B: Outdoor Bathing (Organised)
- D: Propagation of Wild life and Fisheries
- E: Irrigation, Industrial Cooling, Controlled Waste Disposal
- U: Unclassified- Not Classified as 'A' to 'E' or inadequate information
- Discharge = 0 (River Dry)

Figure 3.5: Groundwater Quality of Punjab, 2015

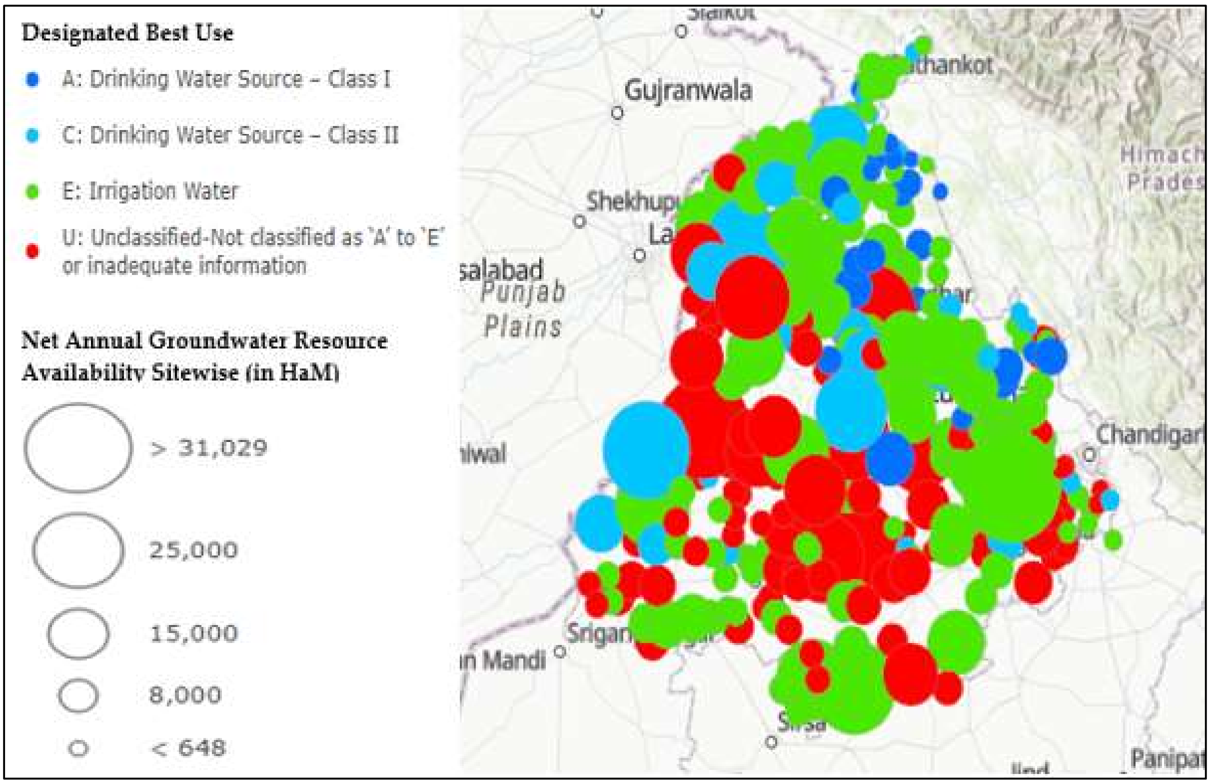
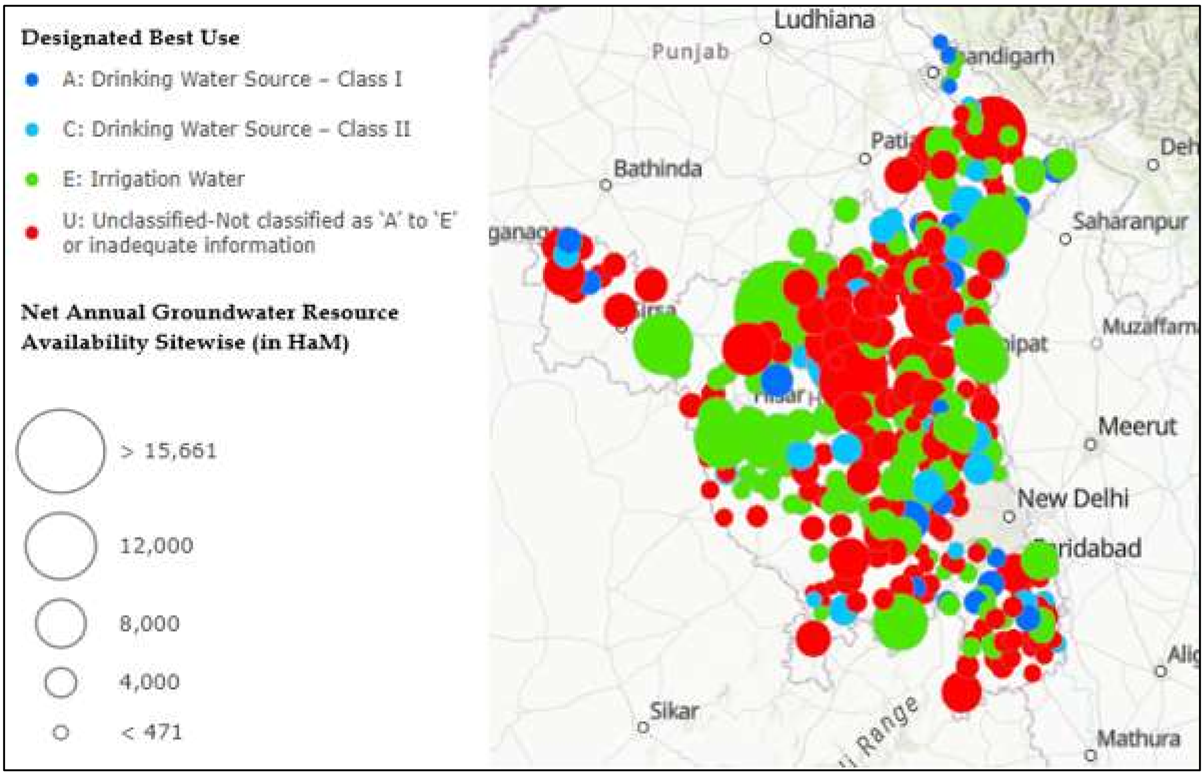
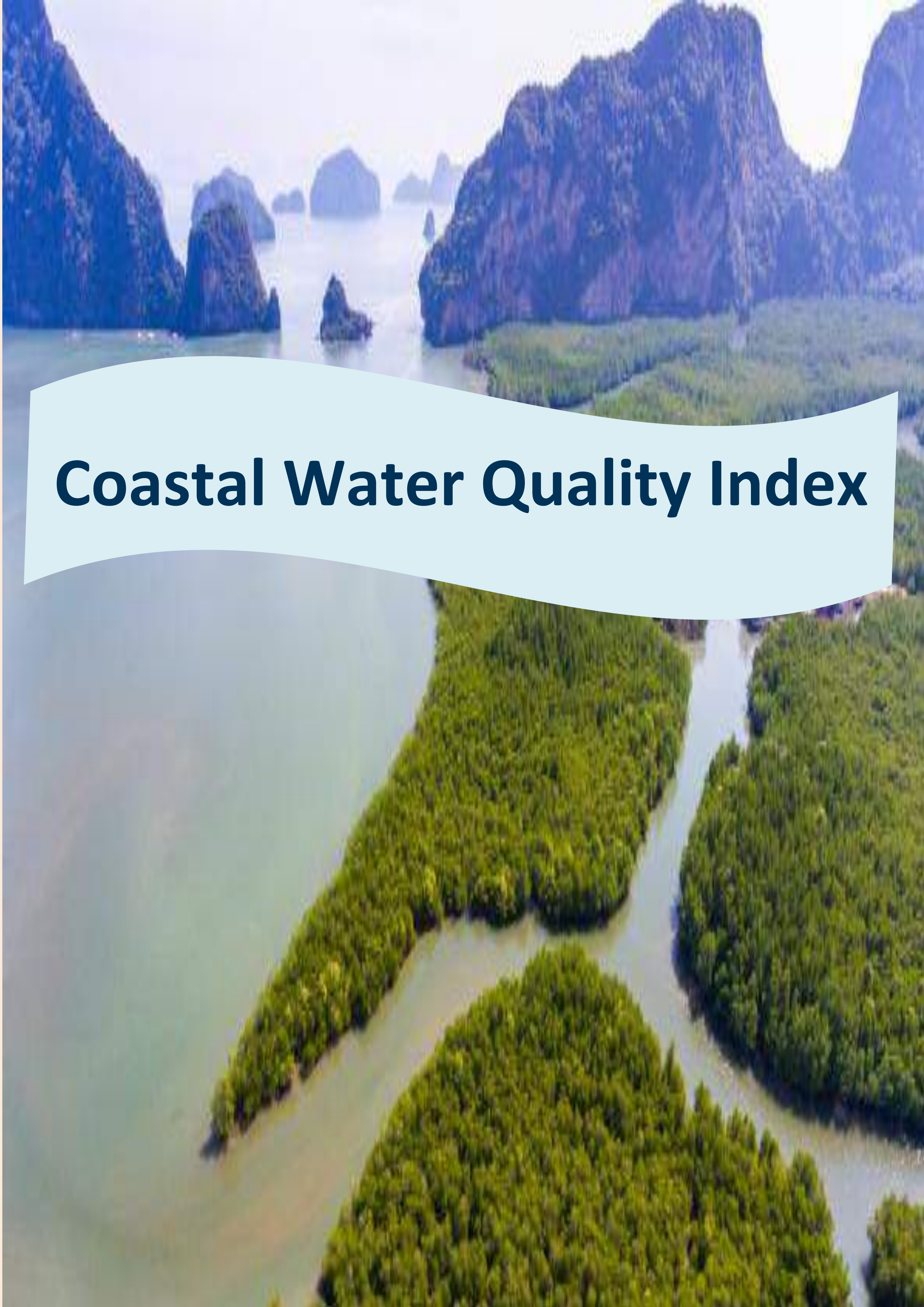


Figure 3.6: Groundwater Quality of Haryana, 2015



Coastal Water Quality Index



Chapter 4

Coastal Water Quality Index

"It is a curious situation that the sea, from which life first arose, should now be threatened by the activities of one form of that life"

Rachel Carson

Introduction

The coastal regions are unique because of their position at the interface of atmosphere, lithosphere and hydrosphere. This interaction creates a wide variety of complex habitats, which host a rich biodiversity, energy and mineral resources. Although coastal ocean covers ~10% of the total area of the ocean, it is estimated[25] that this system provides important ecological and economical services in the form of coastal protection, fisheries and other living and non-living resources. This has made the coastal areas centres of human activity for millennia. It is not by chance that virtually all of the world's major cities are located on coasts and an estimated ~50% of the world's population lives within the coastal regions [26]. The world population is estimated to be 9.8 billion in 2050, and 11.2 billion in 2100 (www.un.org). The increasing human population and rapid boom in industrialization are putting tremendous stress on the coastal systems for their everyday needs. Halpern et al (2008)[27], based on an ecosystem-specific, multi-scale spatial model indicated that no area is unaffected by human and large fractions of the ocean ecosystem (41%) are strongly affected. Consequently, the resources in the coastal ecosystem have become progressively depleted, in some places, to a point of no recovery. Therefore, gradual deterioration of the coast across the globe and the failure to restore the marine ecosystem, even after the cessation of human interference have demanded comprehensive and comprehensible ecological assessment from societal, economic and political heads.

2. India's coastline of about 7500 km spans nine maritime states and five Union Territories including two Island territories. It has 1208 island territories and an Exclusive Economic Zone (EEZ) of 2.2 million sq.km. India has also been allotted by the International

[25] Costanza R, De Groot R, Sutton P, et al. (2014). Changes in the global value of ecosystem services. Glob Environ Change, 26:152–158 (https://www.sciencedirect.com/science/article/abs/pii/S0959378014000685)

[26] Sharpe, M., 2005. The rising tide: combating coastal pollution. J Environ Monit. 7, 401-404

[27] Halpern,B.S,, Walbridge, S., Selkoe, K.A., Kappel, C.V., Micheli, F., 2008. A global map of human impact on marine ecosystems. Science. 319, 948–952 (https://www.ncbi.nlm.nih.gov/pubmed/18276889)

Seabed Authority (ISA) an area of 1.5 lakh sq.km in the Indian Ocean for exploitation of seabed resources. India also has established interests in Antarctica.

3. Fishing is a major economic activity undertaken by India in the seas around it. 2.5 lakh vessels of various kinds are deployed on fishing activities, employing nearly 15 million people directly or indirectly. In addition to providing staple food to millions across the country, it also earns foreign exchange close to $6 billion. India is also prospecting for oil and natural gas in its EEZ. Nearly 20 percent of petroleum needs of India are extracted off shore. India has also been prospecting for oil in far flung corners of the world, extending her maritime interests beyond Indian Ocean into the Pacific and Atlantic regions. Like other countries, as resources on land reduce and with improvement of technology, India too will be looking to exploit its EEZ and the area allocated by ISA for poly-metallic nodules and other resources.

4. Bulk of India's trade is through sea and amounts to 90 percent of trade by volume and 70 percent by value. India has 12 major and 205 notified minor and intermediate ports. Under the National Perspective Plan for Sagarmala, six new mega ports will be developed in the country. The average throughput across the ports of India was about 100 million tonnes per month. A major part of the imports is crude oil and LNG, to meet energy needs of the nation. As the Indian economy and industry grows further, its energy needs would also grow. Indian shipping, ports and supporting industries would therefore play a pivotal role in India's future economic growth. But the downside is the pollution from the ships. The main sources of pollution from ships are:

- Oily-water discharge from ships.
- Tanker accidents.
- Garbage and Other Solid waste.
- Wastewater discharged from ships.
- Accidental spillage during terminal loading.
- Ballast-water discharged from ships at ports.
- Marine Machinery Exhaust.
- Anti-fouling Paints.
- Sound pollution

5. Each of these have a negative effect on one or the other component of the marine ecosystem. While the wastewater discharged from the ships can damage ecosystems, create algal blooms and pose significant human health risks, the garbage and other solid waste may become marine debris, and can then pose a threat to marine organisms, humans, coastal communities, and industries that utilize marine waters. Exhaust emissions from ships are considered to be a significant source of air pollution. The noise produced by ships can travel long distances, and marine species that may rely on sound for their orientation, communication, and feeding, can be harmed by this sound pollution. In fact, the Convention on the Conservation of Migratory Species has identified ocean noise as a potential threat to marine life.

6. The Indian subcontinent with its natural gradient in environmental features, complex oceanography (biannual reversal of surface currents) and unique geological history creates, a number of complex habitats, supporting a diverse biodiversity. Among various types of marine ecosystems in India, tidal mudflats, mangroves, estuaries, lagoons, beaches, marshes, vegetated wetlands and coral reefs have a major share. A total of 97 major estuaries, 34 major lagoons, 31 mangrove areas and 5 coral reefs have been mapped and identified in India for conservation and sustainable use. There are a total of 31 Marine Protected Areas (MPAs) in India, primarily in the marine environment, which cover a total area of 6271.2 km^2 with an average size of 202.1 km^2. East coast and Andaman and Nicobar Islands have adequate areas in the MPAs whereas the west coast and Lakshadweep Islands have poor representation. Also, another 100 PAs (10 in main Indian coast and 90 island PAs in Andaman and Nicobar) have terrestrial or fresh water ecosystems which constitute boundaries with seawater or partially contain marine environment.

7. The conservation of the marine ecosystems is largely linked to coastal zone management activities. However, like most coastal regions of the world, coastal areas of India are densely populated and ~30% of its human population is dependent on the rich exploitable coastal and marine resources. Further, three of the four megacities (Mumbai, Chennai and Kolkata) of India are located along the coast. With urbanisation on the rise, the coastal waters in India, apart from being affected by shipping, are getting heavily polluted also due to disposal of sewage, industrial wastes and agricultural runoff. During 2015, the estimated sewage generated from domestic sources was about 61,754 Million Litres per Day (MLD), of which 38,791 MLD (62%) of untreated sewage is released into the aquatic system (CPCB, 2016)[28]. There are about 490 large and medium scale industries located along the coast in addition to numerous small scale industries. It is estimated that

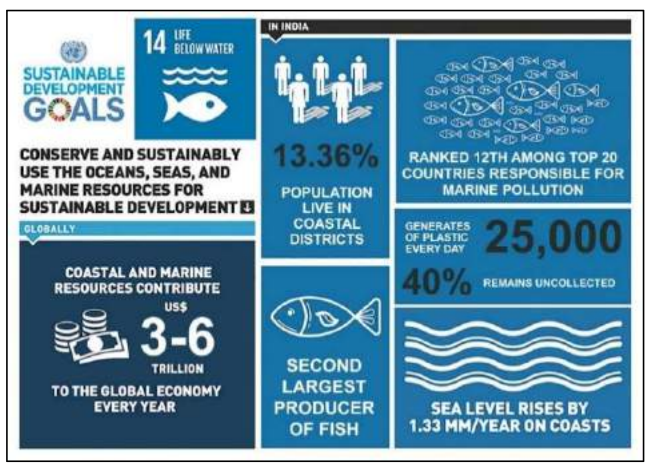
[28] CPCB 2016: CPCB Bulletin, Vol- I, July 2016. Central Pollution Control Board, Ministry of Environment and Forests, Govt. of India, Delhi, India. Available at: https://cpcb.nic.in/openpdffile.php?id=TGF0ZXN0RmlsZS9MYXRlc3RfMTIzX1NVTU1BUllfQk9PS19GUy5wZGY=

about 390 million tonnes of industrial effluents are annually discharged into the coastal waters[29] either directly or through the rivers. Moreover, the use of fertilizers and pesticides to enhance agricultural productivity appears to be increasing every year a fraction of which is ultimately washed into the coastal regions through runoff. Aquaculture, tourism and disposal of wastes from fishing trawlers and small ships are other sources of pollutants to the coastal system, all of which are adding to the stress on these ecologically sensitive and economically important ecosystems.

8. Waste management strategies seem to have failed to keep pace with the rapid urbanization and industrial growth along the coast. Though the sea has capacity to assimilate and degrade several pollutants arising from land-based sources, often even at low concentrations the pollutants accumulate in marine organisms. Over a period of time, depending on the nature of organism, it reaches to toxic levels in the organisms leading to their mortality. When the levels of pollutants reach beyond the assimilative capacity of the sea, the quality of the seawater reaches to the level of degradation when the entire biodiversity reaches to alarmingly low levels and fish production declines drastically. Monitoring the health of coastal waters is, therefore, highly essential to assess the status of pollution, to detect spatial or temporal changes of pollutant levels and to alert the planners and policy makers on levels of marine pollution.

Marine Ecosystems for Sustainable Development

9. The worsening of marine ecosystem is, in fact, rendering considerable economic loss and warrants serious attention of all – policymakers, administrators, scientists and people – towards properly managing the marine ecosystem. The issues related to the marine ecosystem are neither confined to any country or continent nor is it limited to the developing or the developed world. Therefore, the United Nations and other global institutions have been paying attention towards this problem since decades. United Nations has initiated several measures to coordinate the development of environmental policy by keeping the global environment under review and bringing emerging issues to the attention of the governments and the international communities for action. In this context, when the UN General Assembly in its 70th Session adopted an agenda, "Transforming the World: 2030 Agenda for Sustainable Development", one of the 17 goals, SDG 14, was



[29]C.P.R. Environmental Education Centre (http://cpreec.org/pubbook-costal.htm)

exclusively assigned to marine ecosystems. SDG 14 aims "to conserve and sustainably use the oceans, seas and marine resources for sustainable development". The deterioration of coastal waters has become a global occurrence, due to pollution and coastal eutrophication (overflow of nutrients in water), where similar contributing factors to climate change can affect oceans and negatively impact marine biodiversity. Effective strategies to mitigate adverse effects of increased ocean acidification are, therefore, needed to advance the sustainable use of oceans.

Need for Marine Water Quality Indices

10. To assess the impact of various anthropogenic activities and natural processes on the coastal ecosystem, it is necessary to monitor long-trends along the coastal waters for important environmental and biological parameters. Therefore, countries are regularly monitoring and assessing the quality of coastal waters. Such monitoring programmes generate large datasets for several coastal variables. Success of such monitoring programmes depends on the transfer of knowledge gathered or generated to the policy makers, non-technical water managers and the public in an easily understood format. This will allow them to take decisions on sound scientific basis. However, the task of simplifying the enormous abiotic and biotic data is not straightforward. The concept of a Water Quality Index (WQI) offers a useful framework to transform complex datasets into a compact form that can facilitate monitoring the health of the coastal waters and also aid in designing specific pollution prevention programs. Further, it allows determining whether goals such as compliance with pollution regulations or implementation of effective pollution control actions are being met.

Index for coastal waters in India

11. India has national and international obligations to prevent adverse effects to marine ecosystems caused by various anthropogenic activities. To help monitor long-trends along the coastal waters of the country, the Ministry of Earth Sciences (MoES), formerly the Department of Ocean Development (DOD) has been implementing a nationally co-ordinated research programme on, 'Coastal Ocean Monitoring and Prediction System (COMAPS)' since 1990. Under this programme, long term data was being collected at regular intervals using consistent methods that could be used to generate valuable knowledge about the ecosystem processes and could help environmental managers develop effective management plans. In 2010, review of the programme by an expert panel resulted in restricting the number of monitoring locations from 81 to 24. Further, COMAPS programme has been renamed as "Seawater Quality Monitoring (SWQM)". The primary objective of SWQM programme is systematic monitoring of seawater quality along Indian

coast at selected locations, identified based on the sources of marine pollutants. To achieve this objective, the National Centre for Coastal Research (NCCR) coordinates the monitoring activities with the participation of National institutes and academia. Under the programme – COMAPS/ SWQM - data on more than 25 parameters on physico-chemical, biological and microbiological characteristics of seawater and sediment are being seasonally collected and analysed using standard protocols. Water (surface, mid-depth and bottom) and sediment samples are being collected in each location at 0/0.5 km (shore), 2/3 km (nearshore) and 5 km (offshore) distance from the shore.

12. Coastal monitoring programme developed indices using several parameters based on the following categories[30]:

Category I: degree of nutrient enrichment;
Category II: direct effects of nutrient enrichment; and
Category III: indirect effects of nutrient enrichment

Developing a simple water quality index requires selecting one or two parameters from each category as indicators. Globally, Dissolved Inorganic Nitrogen (DIN) and Dissolved Inorganic Phosphorus (DIP) are the potential parameters identified for the assessment of eutrophication from Category I, surface Chlorophyll-a (Chl-a) as an indicator from Category II as it reflects the immediate response for enrichment of nutrients and bottom DO as an indicator from Category III because it is a critical parameter for sustenance of ecosystem diversity[31,30]. In the Indian context, disposal of sewage is the major threat to the coastal waters. The major fraction of sewage in India is released untreated or with minimal treatment (CPCB 2016)[28], consequently bringing enormous loads of organic matter along with pathogenic microbial population to the coastal waters. In the recent years, organic forms of nutrients were found to contribute more than 70% of total nutrient pools in the coastal waters. Hence, pollution monitoring programmes in India provide wider attention to total or organic form of nutrients rather than the inorganic forms i.e. DIN & DIP.

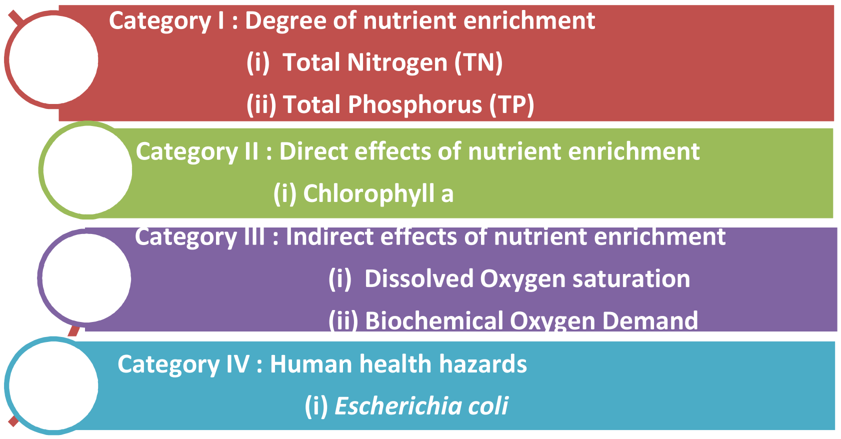
13. An index developed for the Indian coastal waters without considering total nitrogen (TN), total phosphorus (TP) and bacterial loads (in particular faecal coliforms) would be an underestimation of the water quality. For this reason, along with the above listed categories, faecal coliforms were considered as an indicator under Category IV:

[30] US EPA, NCCR, 2012. National Coastal Condition Report IV 334. doi:EPA-620/R-01/005

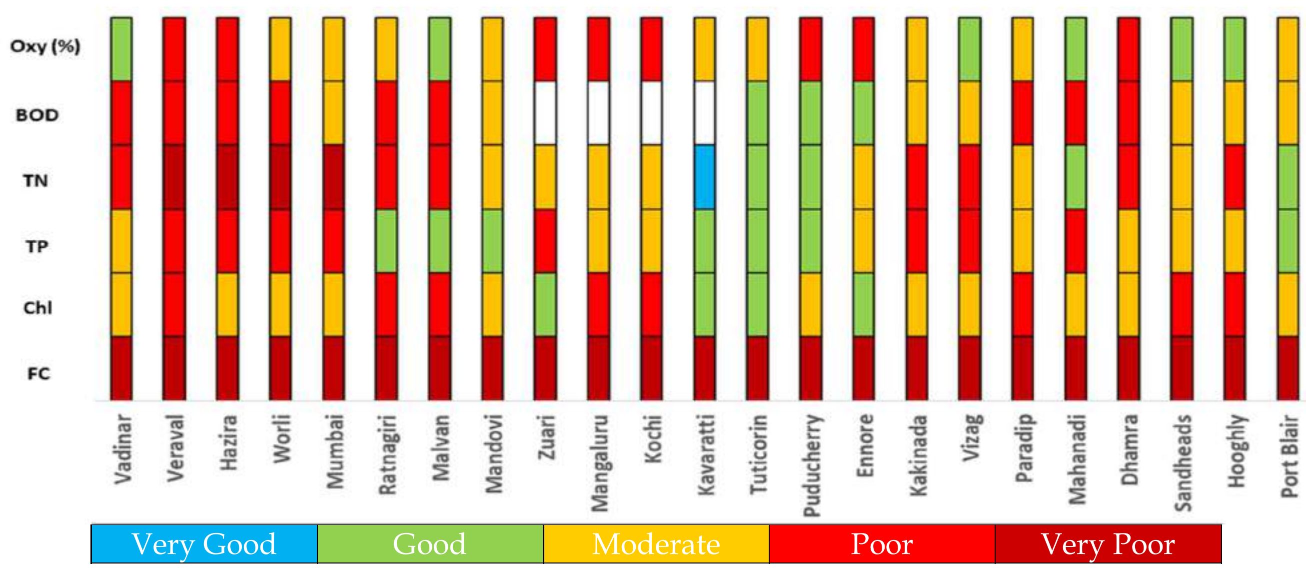
[31] OSPAR Procedure, 2005. Synergies between the OSPAR Comprehensive Procedure, the integrated set of OSPAR Ecological Quality Objectives (EcoQOs) for eutrophication and the EC Water Framework Directive OSPAR Commission

Human health hazards to the index calculation. **Figure 4.1** gives the parameters used by NCCR[32] for compiling water quality indices for the sites.

Figure 4.1. Parameters considered for calculating WQI



Based on threshold value, **Figure 4.2** below gives the grades of the different indicators at different monitoring locations.



14. The quality or accuracy of any WQI method relies on the definition of thresholds for selected indicators. Thus, the establishment of thresholds for each indicator should be robust and logical. For compiling the WQI for seawater, NCCR has adopted the methodologies of Integration and Application Network, Center for Environmental Science, University of Maryland used for the development of Eco Health Report Cards[33]. The main objective for deriving the WQI using the SWQM data was to find out the spatial extent of anthropogenic impacts (i.e. sewage and domestic discharges) on the coastal water

[32] Seawater Quality at Selected Locations along Indian Coast – Status Report (1990-2015), Ministry of Earth Sciences, Government of India

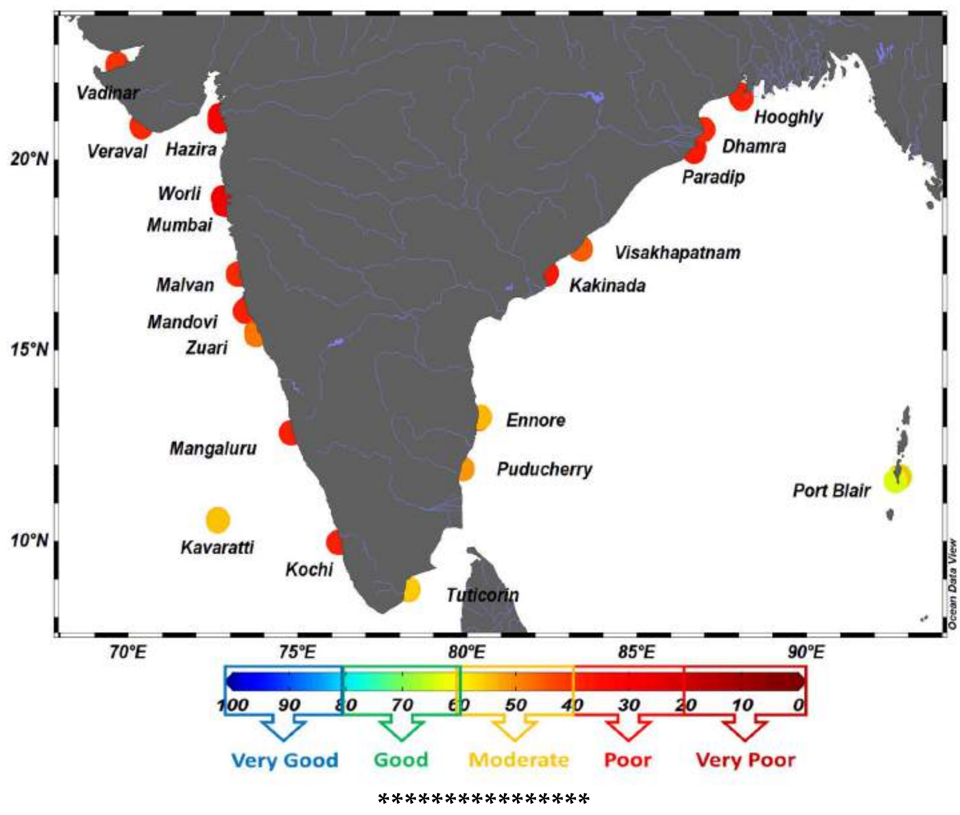
[33] Eco Health Report Cards (https://ecoreportcard.org/)

quality, hence SWQM/COMAPS dataset of all the stations (ranging from hotspots, 0.5 km, 2.0 km & 5.0 km) from each monitoring location collected during the recent years (2011-2015) were considered to derive thresholds for each indicator. Multiple thresholds were used to score indicators based on a gradient of healthy to unhealthy conditions by diving the data in equal percentiles. Cumulative scores for each parameter were converted to 0-100% grading scale and reported as WQI.

15. In respect of the aggregate index, WQI at Vadinar, Veraval, Hazira, Worli, Mumbai, Malvan, Mangaluru and Kochi along west coast; Kakinada, Paradip and Dhamra along the east coast obtained 'Poor' status. Stations viz. Zuari, Tuticorin, Puducherry, Ennore were found to be in 'Moderate' condition. In general, based on the WQI, 11 out of 21 locations were found to be in 'Poor' condition, and the remaining locations were in 'Moderate' condition. Locations at Port Blair and Kavaratti were found to be in 'Moderate' and 'Good' condition.

16. WQI were developed for each station and five years' average index for each station were used for the preparation of location wise WQI maps **(Figure 4.3)**.

Figure 4.3. Water Quality Index map for the period 2011-2015



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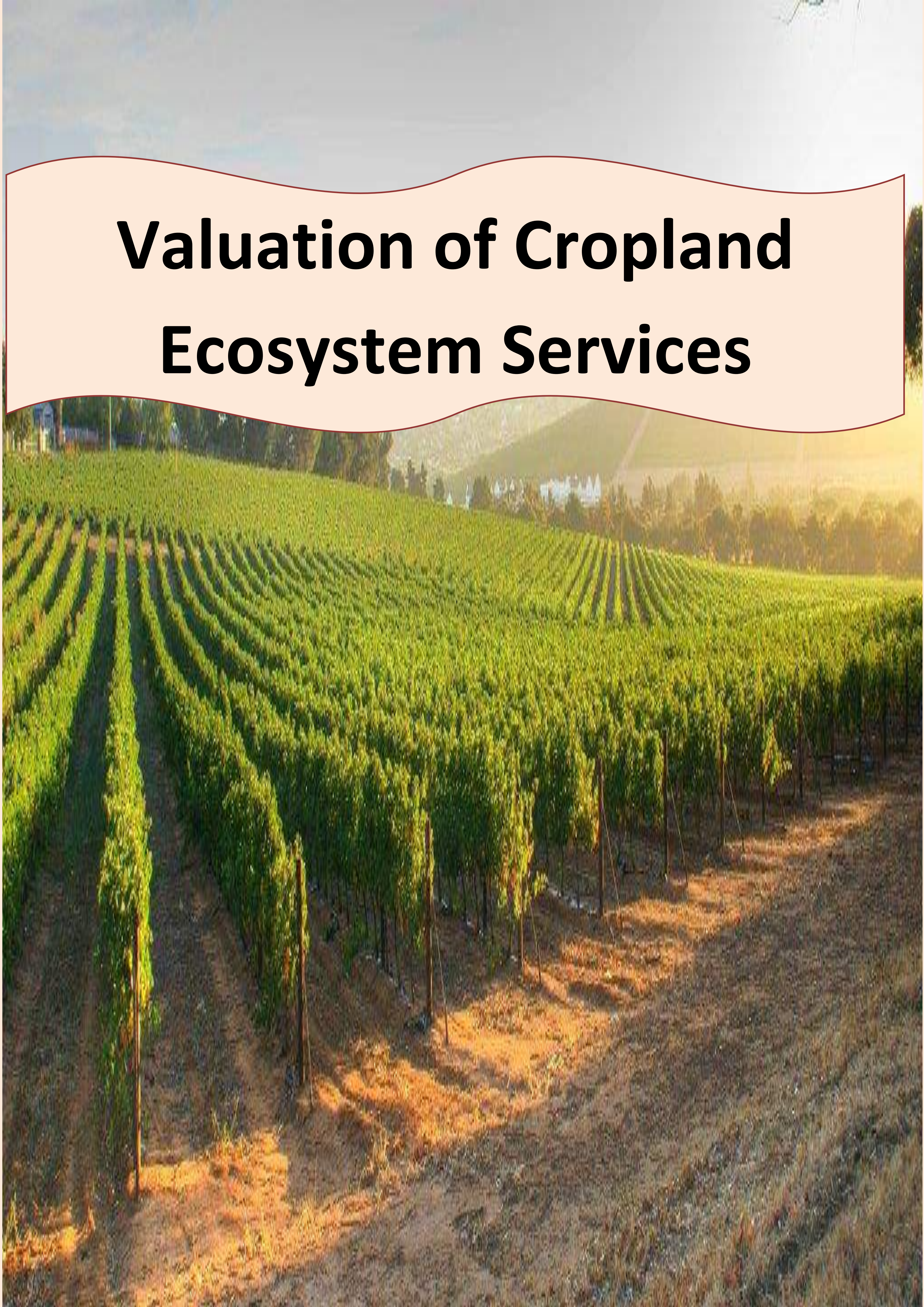
Valuation of Cropland Ecosystem Services



Chapter 5

Valuation of Cropland Ecosystem Services

"Agriculture is our wisest pursuit, because it will in the end, contribute most to real wealth and happiness"

Thomas Jefferson

Introduction

Agriculture and allied sectors are pivotal to the sustainable growth and development of any country, but is significantly marked in the Indian context. Not only does it meet the food and nutritional requirements of 1.3 billion Indians, agriculture is the primary source of livelihood for about 58 per cent of India's rural households or 40 percent of the total households. As per the NSS Situation Assessment Survey[34] conducted during 2012-13, agricultural activity was reported to be the principal source of income for majority of the households in all the major States, except Kerala. Uttar Pradesh, with an estimate of 18.05 million agricultural households, accounted for about 20 percent of all agricultural households in the country, while Rajasthan had highest percentage of agricultural households (78.4 percent) among its rural households. Even the lowest percentage share of agricultural households in rural households was a significant 27.3 percent in Kerala. The sustainability of these farmers is crucial for livelihoods in rural areas and for the entire country.

2. It is well-documented that the forward and backward linkage effects of agriculture growth increase the incomes in the non-agriculture sector. The growth of some commercial crops has significant potential for promoting exports of agricultural commodities and bringing about faster development of agro-based industries. Thus agriculture not only contributes to overall growth of the economy but also reduces poverty by providing employment and food security to the majority of the population in the country and thus it is the most inclusive growth sectors of the Indian economy.

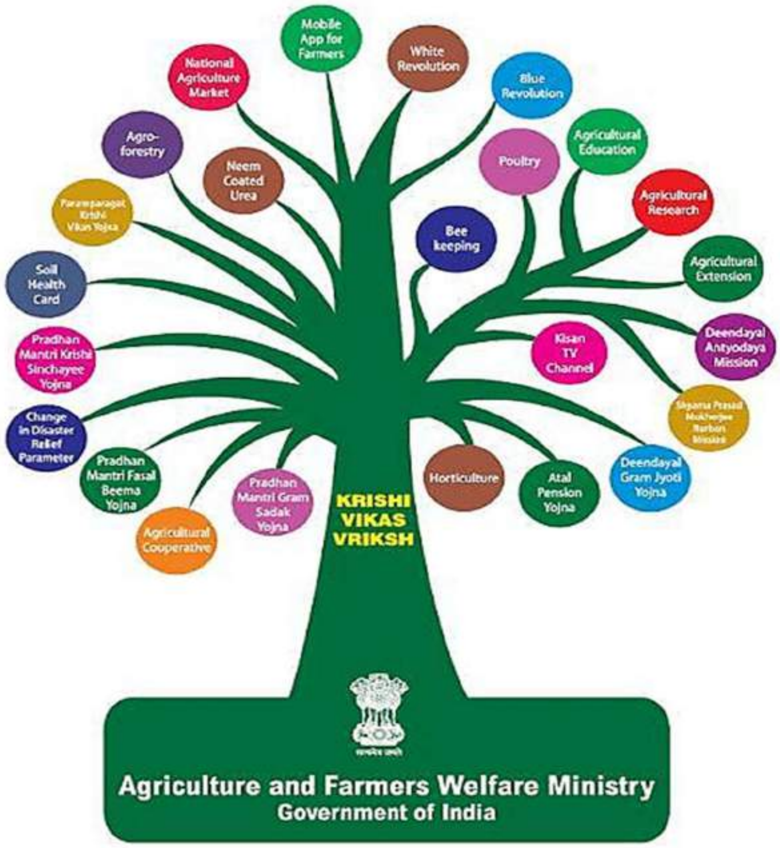
3. The sector is, however, plagued with several issues. The above-cited NSS Survey estimates the average gross cropped area per agricultural household during 2012-13 was

[34] Key Indicators of Situation of Agricultural Households in India(NSS 70th Round),MOSPI http://mospi.nic.in/sites/default/files/publication_reports/KI_70_33_19dec14.pdf

0.937 hectare. Land fragmentation is said to harm productivity in a number of ways. First, fragmented land holdings can increase transport costs. If the plots are located far from the home, and far from each other, there is a waste of time for the workers spent on travelling in between the plots and the home. Management, supervision and securing of scattered plots can also be more difficult, time consuming, and costly. Small and scattered plots and waste land area require more land for fencing, border constructions, and paths and roads. Small fragmented land holdings might also cause difficulties to grow certain crops, and prevent farmers from changing to high profit crops. More profitable crops, like for example fruit crops, require larger plot areas, so if the farmers only possess small and fragmented plots they may be forced to grow only less profitable crops. Another aspect is that of the irrigation infrastructure. Since independence, there has been a rapid expansion of irrigation infrastructure in India. However, despite the large scale expansion, only about one third of total cropped area is irrigated today and two third of cropped areas is still dependent upon monsoon. So, with the options for utilising newly emerging technologies and mechanisation being limited in the case of small-holdings, which generally are also monsoon dependent, the cost of cultivation per hectare is generally high in small and marginal farms than medium and large farms and consequently, net farm income per hectare is in large holdings higher than that in small holdings.

4. To counter these issues, a number of initiatives have been taken up by the Government in the interest of farmers like distribution of Soil Health Cards, nutrient-based subsidy(NBS) policy for P and K fertilizers, organic farming, Pradhan Mantri Krishi Sinchai Yojana (PMKSY), Paramparagat Krishi Vikas Yojna (PKVY), National Mission on Sustainable Agriculture (NMSA), National Agriculture Market scheme (e-NAM), National Water Mission, National Mission for a Green India and Mission for Integrated Development of Horticulture. A 24-hour television channel named DD Kisan and a toll-free Kisan Call Centre have also been launched for Indian farmers to help in sorting out any kind of agricultural problems. The Krishi Vikas Vriksh shown in **Figure 5.1** given below depicts several initiatives /schemes launched by Government of India.

Figure 5.1. Krishi Vikas Vriksh



5. In respect of farmers with small holdings[35], apart from the above-mentioned initiatives, under the Pradhan Mantri Kisan Samman Nidhi Yojana (PM-Kisan), Rs. 2,021 crore was transferred to the bank accounts of more than 10 million small and marginal farmers as minimum income support on February 2019. Earlier in September 2018, the Government of India announced Rs 15,053 crore procurement policy named 'Pradhan Mantri Annadata Aay Sanrakshan Abhiyan' (PM-AASHA), under which states can decide the compensation scheme and can also partner with private agencies to ensure fair prices for farmers in the country. To enable the farmers' cooperatives in getting maximum benefits of digital technology, the government has provided Rs. 2,000 crore for computerisation of Primary Agricultural Credit Society (PACS). A new AGRI-UDAAN programme has been introduced to mentor start-ups and to enable them to connect with potential investors with an aim to boost innovation and entrepreneurship in agriculture.

6. Even though the share of the farm sector is reducing in the economy, with the progress in agriculture directly linked to the achievement of several Sustainable Development Goals (see **Figure 5.2**), the sector needs more emphasis than ever before.

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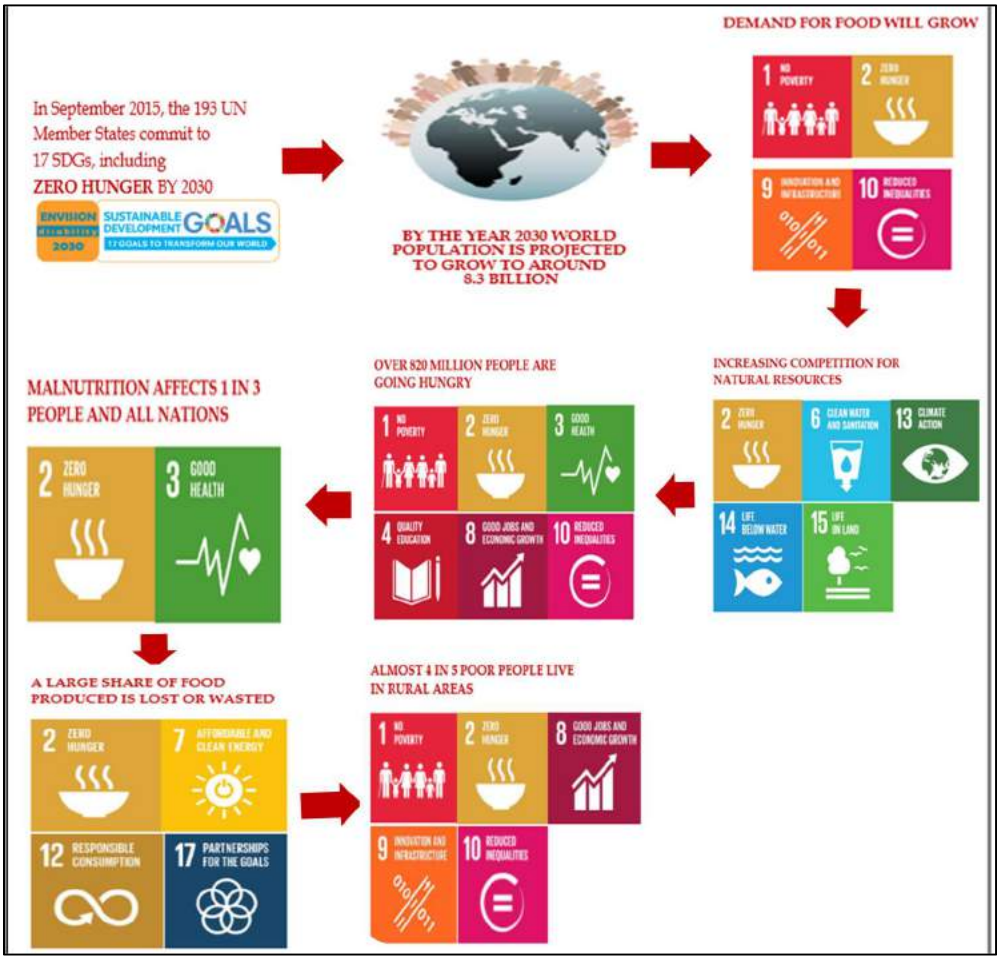
[35] Various press releases of the Ministry of Agriculture and Farmers Welfare; https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1568060

Figure 5.2: Agriculture and SDGs



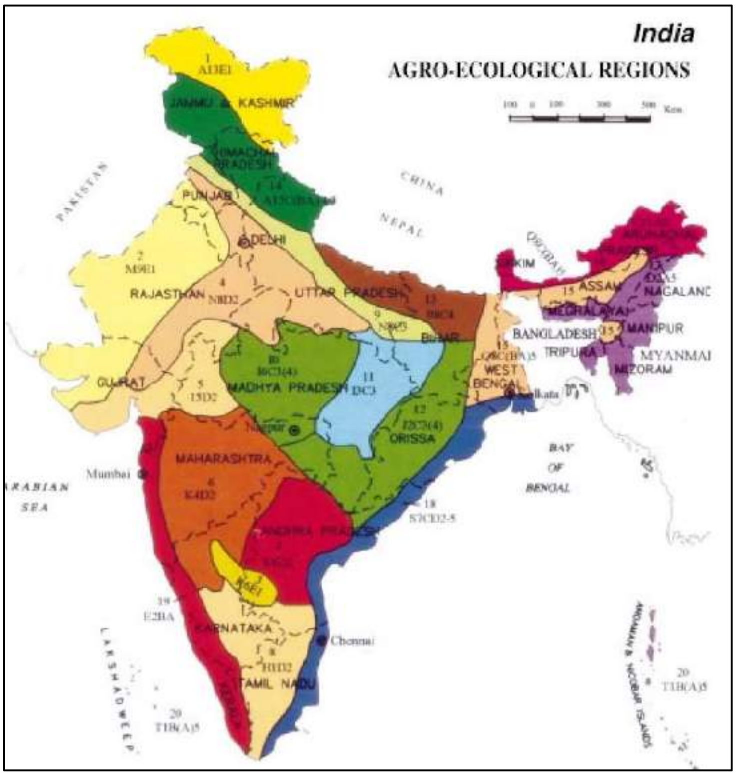
Agricultural ecosystems

7. Agroecosystems are both providers and consumers of ecosystem services. Humans value these systems chiefly for their provisioning services, and these highly managed ecosystems are designed to provide food, forage, fibre, bioenergy and pharmaceuticals. The contribution of the ecosystem to crop production, i.e. the total and combined result of processes taking place in cropland that support crop production such as infiltration of water, the absorption of plant nutrients by soil particles and the resupply of these particles to plants (nutrient cycling), soil retention and regulation of soil fertility. Whether any particular agricultural system provides such services in support of provisioning depends on management, and management is influenced by the balance between short-term and long-term benefits.

8. Management practices also influence the potential for 'disservices' from agriculture, including loss of habitat for conserving biodiversity, nutrient runoff,

sedimentation of waterways, and pesticide poisoning of humans. However, appropriate management can ameliorate many of the negative impacts of agriculture, while largely maintaining provisioning services.

9. The diversity of India is unique and presents endless varieties of physical features and cultural patterns. With a cropland spanning an area of about 156 million hectares[36], India is a vast country with great diversity of physical features like dry deserts, evergreen forests, snowy Himalayas, a long coast and fertile plains. Certain parts in India are so fertile that they are counted amongst the most fertile regions of the world, while other are so unproductive and barren that hardly anything can be grown there. From the point of climate too, there is a sharp contrast; India has every variety of climates from the blazing heat of the plains, as hot in places as hottest Africa to freezing points of the Himalayas as in the Arctic. Consequently, the agricultural ecosystems in India show tremendous variation, as they are driven by diverse cultures under diverse socioeconomic conditions in diverse climatic regions. India has 20 different agro-ecological regions and 60 agro-ecological sub-regions.



10. The agricultural practices in India include, among others, subsistence farming, plantations, rotation farming, annual crop monocultures, temperate perennial orchards, shifting cultivation systems, smallholder mixed cropping systems, paddy rice systems and terrace cultivation. Also, India has three distinct agricultural/cropping seasons viz. kharif, rabi and zaid. In India there are specific crops grown in these three seasons. For example, rice is a kharif crop whereas wheat is a rabi crop. This variety of agricultural systems results in a highly variable assortment and quantity of ecosystem services.

[36] National Remote Sensing Centre, LULC, 2011-12; as retrieved from http://www.mospi.gov.in/sites/default/files/reports_and_publication/statistical_publication/EnviStats/3_Chapter%201-%20Land.pdf

11. In maximizing the value of provisioning services, agricultural activities are likely to modify or diminish the ecological services provided by unmanaged terrestrial ecosystems, but appropriate management of key processes may improve the ability of agroecosystems to provide a broad range of ecosystem services.

Approaches for Analysing Ecosystem Services

12. The overarching goal of measuring and valuing ecosystem services is to use that information to shape policies and incentives for better management of ecosystems and natural resources. SEEA prescribes the use of 'resource rent method' for estimating the value of this ecosystem service provided by croplands. The measurement of Resource Rent provides a gross measure of the return to crop production. Since households have a high level of ownership or influence over farming on Agricultural Land, valuation of Resource Rent in monetary terms may also provide useful information for assessing future streams of income from Agricultural Land for households.

13. Valuation of Resource Rent helps to compare Agricultural Land with different environmental assets using a common numeraire. Agricultural Land can be compared against other assets in order to assess relative returns, national wealth and similar types of analysis. One of the methods prescribed in SEEA for estimating the resource rent is the appropriation method. The **appropriation method** estimates the resource rent using the actual payments made to owners of environmental assets. Legal owners collect the entire resource rent (in terms of rental value of owned land or rent paid for leased-in land) derived from extraction of the resources that they own.

Sources of statistics on different aspects of agriculture in India[37]

14. Ministry of Agriculture and Farmers Welfare, Government of India, collects and collates various types of data on different facets of agriculture. Price policy for agricultural commodities constitutes an important element of overall agricultural economic policy in India. Minimum Support Prices (MSPs) for important cereals, pulses, oilseeds, and other commercial crops, namely, cotton, jute and sugarcane, are fixed by the Government every year on the basis of the recommendations made by the Commission for Agricultural Costs and Prices (CACP). The most important factor considered by the CACP in making its recommendations on MSPs for different crops is the cost of cultivation/production for which the database is provided by the Directorate of Economics and Statistics (DES) of the Ministry of Agriculture & Farmers Welfare through a study on cost of cultivation. CACP also take into account the advance information on the production of different crops, supply-demand scenario, as well as price movements in both the domestic and international markets, while making these recommendations.

[37] http://eands.dacnet.nic.in/rti/Annex%20I.htm

15. The effectiveness of price policy in boosting production and productivity of agriculture in tune with domestic as well as external demand cannot be assessed in the absence of regular data on area, production and yield of different crops. Similarly, data on domestic and international prices for various agricultural commodities, trends in procurement, offtake and stocks of foodgrains, consumption of different agricultural commodities, their exports and imports, etc. assume immense significance in the emerging external economic environment, which is increasingly influenced by the World Trade Organisation. The importance of a sound data/ information base on different facets of agriculture cannot therefore be overemphasized. The DES has several schemes to cater to these needs of datasets on the agriculture in India. The key points of these schemes are given in the following paragraphs.

I. Comprehensive Scheme for Studying the Cost of Cultivation of Principal Crops in India

16. The Comprehensive Scheme for Studying the Cost of Cultivation of Principal Crops in India is being implemented since 1970-71, with the following objectives:

(i) collection and compilation of field data on cost of cultivation and cost of production in respect of 28 crops; and

(ii) generation of estimates of cost of cultivation and cost of production of various crops in different States covered under the scheme.

17. DES gets this study conducted in 19 States through Agricultural and other Universities covering 28 crops. Under the scheme, the field data pertaining to the cost of cultivation/ cost of production are collected, compiled and analysed. The study covers both the cash and non-cash costs. The cash costs include the costs for which farmer spends money for acquisition of material inputs like seeds, fertilizer, chemicals or labour inputs like hired labour etc. On the other hand, non-cash costs are attributable to items of cost, which do not require spending money. These may be items of cost like family labour, payments made in kind, home grown seeds, manure etc., exchange labour, depreciation, interest on operating capital etc. The field data under the scheme are collected on the Cost Accounting Method under which daily entries of debit/credit for the expenditure/income are made in order to assess the total cost incurred/benefit accrued by/ to each farmer covered under the scheme. The detailed questionnaire is filled up/updated on monthly/annual basis after making enquiries on daily basis from farm holdings distributed equally across different size classes.

II. Improvement of Agricultural Statistics

18. The basic objective of this Scheme is to collect and improve agricultural statistics of Principal Agricultural Crops and selected Horticultural Crops. The Scheme has four components namely (i) Timely Reporting Scheme, (ii) Improvement of Crop Statistics, (iii) Establishment of an Agency for Reporting of Agricultural Statistics (EARAS) and (iv) Crop Estimation Survey on Fruits & Vegetables.

19. The scheme has different components, but primarily, the objective is to obtain estimates of area and production of the identified principal crops, in each season, with break-up of area under irrigated/unirrigated and traditional /high yielding varieties of crops on the basis of priority enumeration conducted on the basis of random sample of 20% of villages by a specific date. The scheme also has provision for supervision and monitoring to improve the quality of statistics through a sample check of area enumeration and crop-cutting experiments.

III. Land Use Statistics

20. Land Use Statistics is a comprehensive and systematic account of natural endowment of land spanning over 328 million hectares of geographic space of the country, adopting the uniform concept of nine-fold land use classification. Crop area statistics is the major segment of LUS. Crop statistics assimilates the diverse agro climatically influenced crop acreage and production details of numerous crops, grown over 140 million hectares of net sown area with about 141 percent cropping intensity. The area statistics broadly covers the utilisation pattern of land with detailed statistics relating to land put to agricultural uses. This includes the area sown under different crops in different seasons.

Methodology Used for Estimating Resource Rent

21. Three main sources of information that have been used for this compilation are:

i. Cost of Cultivation Studies
ii. Information on Area, Production and Yield (APY) of major crops
iii. Land Use Statistics

22. The steps followed for the compilation are as under:

i. Rent for CCS States and CCS Crops

- Total rent per hectare, as the sum of rent paid for leased in land or rental value of own land, is taken as it is for the state x crop combination that is available in CCS. In the analysed dataset, there were 19 CCS States and 24 CCS Crops.

- Rent per hectare is then imputed for all states & all crops that are available in CCS. For states where CCS in not available for some crops, missing rent is imputed crop-wise using rent from the neighbouring state.
- For states where CCS in not available for some crops and CCS of those crops is also not available in neighbouring states, rent is imputed with minimum rent of that state itself.

ii. Imputation for Non-CCS States & CCS Crops

- For Non-CCS States, rent for the CCS crops has been imputed from the nearest CCS neighbour.

iii. Imputation for Non-CCS Crops

- For crops where CCS in not available for any state, rent has been imputed with positive minimum rent of that state itself.

iv. Since crop-wise information is available for Gross Area Sown and not Net Area Sown, an adjustment factor has been derived from Land Use Statistics.

- Adjustment factor for Net Area Sown = Net Area Sown/Gross Area Sown

Resource Rent for State for a Crop for a Year

v. $RR(S)_{crop}$ = [{ Rent per hectare (State) x Area under crop (State) x Adjustment for Net Area Sown]

Resource Rent for State per unit quantity[38] of Crop for a Year

vi. $RR(S)_{crop}$ per tonne = $RR(S)_{crop}$ / [Production (State)]

Resource Rent for District for a Crop for a Year

vii. RR(D)crop = RR(S) crop per tonne x Production (district)

Total Resource Rent for a district for a Year

viii. RR(D) = total of all crops as given in APY

23. Valuation of cropland ecosystem service has been done using a three-year average of Resource Rent (per tonne) to remove volatility in Resource Rents over time/years; for instance, average of 2004-05, 2005-06 & 2006-07 has been taken for the year 2005-06. Considering multiple years is expected to negate excessive fluctuations due to contingent events that happened in specific years. Resource rent in the publication has been shown for the years 2005-06, 2011-12 and 2014-15 in terms of Resource rent per unit of geographic area of the district. This shows the combined contribution of land resources in agriculture, as well as the share of crop land in the district.

24. The quintile distribution of the districts for these estimates for the years 2005-06, 2011-12 and 2014-15 are given in **Tables 5.1 to 5.3**, while the corresponding maps are given in **Figure 5.3**. The district-wise detailed estimates for the three years are given in **Statement 5.1.**

[38] Tonnes for all crops, except coconut, where the production is given in 'nuts'.

Table 5.1: Quintile Distribution of Districts in respect of Resource Rent, 2005-06

	2005-06						2005-06
State	Very Low	Low	Medium	High	Very High	No Data	Total
Andaman and Nicobar Islands	1						1
Andhra Pradesh		3	7	8	4	1	23
Arunachal Pradesh	16						16
Assam	6	15	6				27
Bihar	2	4	13	16	3		38
Chandigarh		1					1
Chhattisgarh	4	6	5	2			17
Dadra and Nagar Haveli			1				1
Daman and Diu	1	1					2
Delhi		1					1
Goa		1					1
Gujarat	1	6	11	5	2		25
Haryana			1	2	17		20
Himachal Pradesh	7	5					12
Jammu and Kashmir	7	5	1				13
Jharkhand	19	3					22
Karnataka	1	7	10	9			27
Kerala			2	3	9		14
Madhya Pradesh	3	14	15	15	1		48
Maharashtra	2	15	13	3		2	35
Manipur	5		4				9
Meghalaya	7						7
Mizoram	8						8
Nagaland	6	1		1			8
Odisha	3	14	6	7			30
Puducherry			1	1	2		4
Punjab					17		17
Rajasthan	9	5	6	11	1		32
Sikkim	1	3					4
Tamil Nadu		4	10	12	3	1	30
Telangana							
Tripura		1					1
Uttar Pradesh	1	1	3	20	45		70
Uttarakhand	9	2			2		13
West Bengal			3	3	12	1	19

Demarcation of Classes:

Very Low- < Rs. 586	Low – Rs. 586 to Rs.1339	Medium – Rs. 1339 to Rs. 2119
High – Rs. 2119 to 3643	Very High – Rs. 3643 to Rs. 12222	

Table 5.2: Quintile Distribution of Districts in respect of Resource Rent, 2011-12

	2011-12						2011-12
State	Very Low	Low	Medium	High	Very High	No Data	Total
Andaman and Nicobar Islands	1						1
Andhra Pradesh		5	4	8	5	1	23
Arunachal Pradesh	16						16
Assam	3	17	7				27
Bihar	1	3	21	12	1		38
Chandigarh		1					1
Chhattisgarh	7	8	8	3	1		27
Dadra and Nagar Haveli		1					1
Daman and Diu	1	1					2
Delhi							
Goa		1					1
Gujarat	1	8	10	6	1		26
Haryana			1	2	18		21
Himachal Pradesh	9	3					12
Jammu and Kashmir	14	7	1				22
Jharkhand	20	4					24
Karnataka	1	9	10	8	2		30
Kerala				6	8		14
Madhya Pradesh	1	14	11	19	5		50
Maharashtra	2	6	14	10	1	2	35
Manipur	5		1	3			9
Meghalaya	6	1					7
Mizoram	8						8
Nagaland	10		1				11
Odisha	5	13	4	3	5		30
Puducherry			2	2			4
Punjab	1				21		22
Rajasthan	3	13	8	9			33
Sikkim	4						4
Tamil Nadu		5	17	6	3	1	32
Telangana							
Tripura		1					1
Uttar Pradesh		1	4	21	46		72
Uttarakhand	8	3		1	1		13
West Bengal		1	2	7	8	1	19

Demarcation of Classes:

Very Low- < Rs. 1033	Low – Rs. 1033 to Rs.2724	Medium – Rs. 2724 to Rs. 4069
High – Rs. 4069 to 7303	Very High – Rs. 7303 to Rs. 34816	

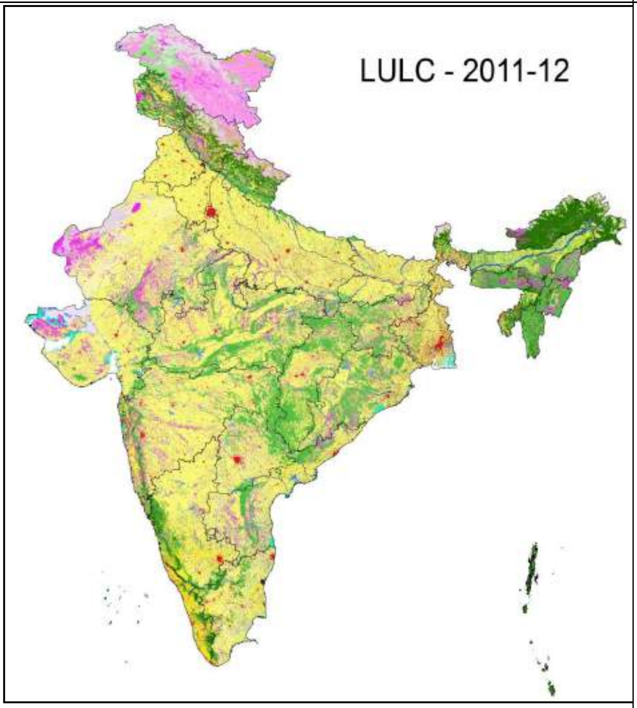
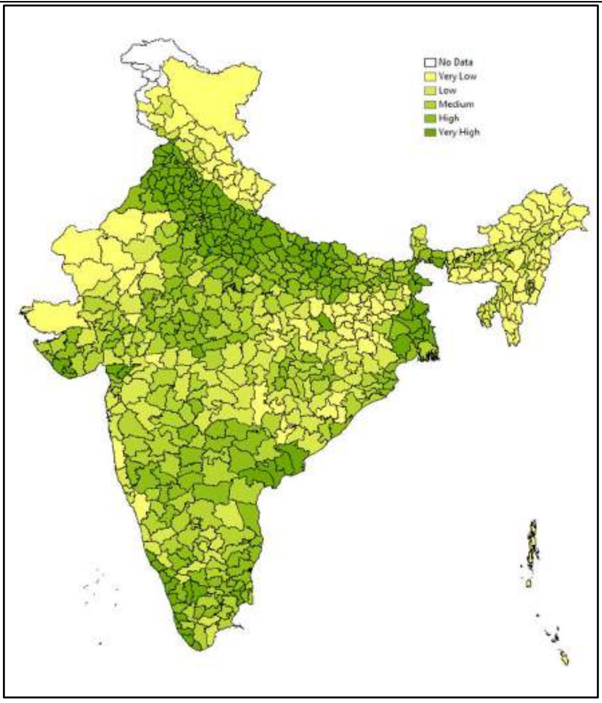
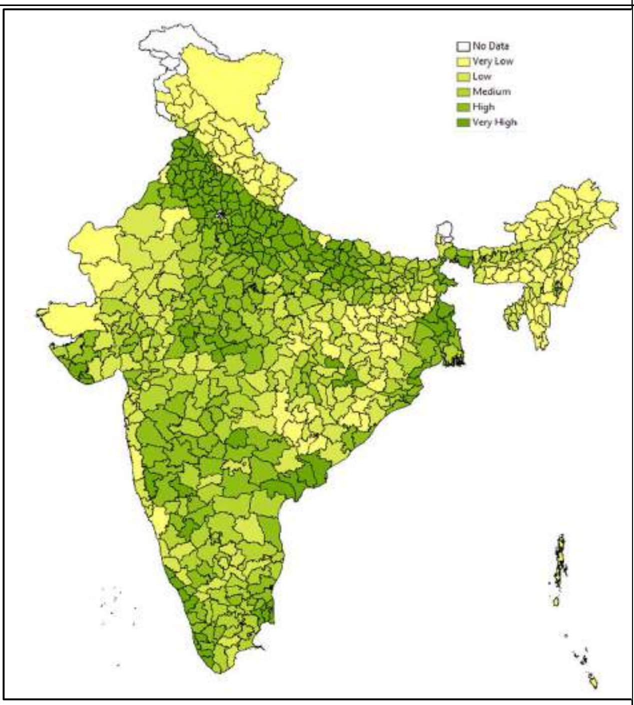
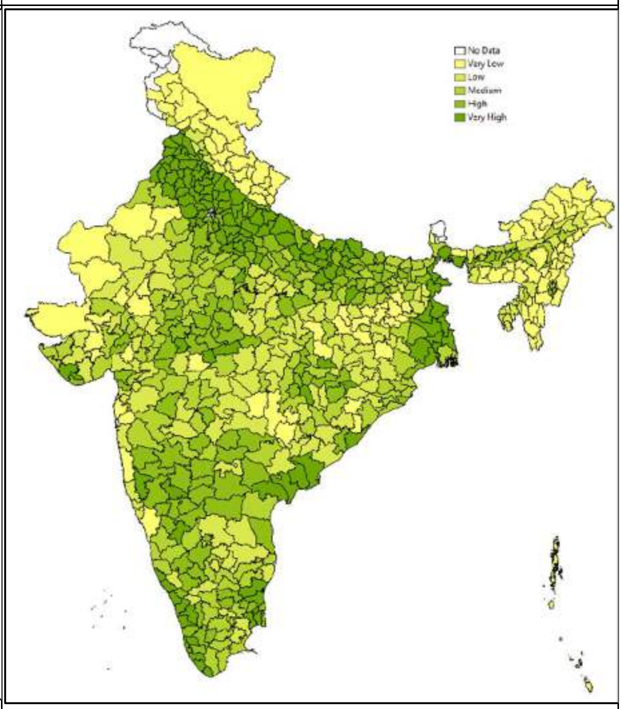
Table 5.3: Quintile Distribution of Districts in respect of Resource Rent, 2014-15

	2014-15						2014-15
State	Very Low	Low	Medium	High	Very High	No Data	Total
Andaman and Nicobar Islands	1						1
Andhra Pradesh		4	1	3	5		13
Arunachal Pradesh	18						18
Assam	2	10	10	5			27
Bihar	1	1	16	18	2		38
Chandigarh		1					1
Chhattisgarh	5	7	7	6	2		27
Dadra and Nagar Haveli		1					1
Daman and Diu	1	1					2
Delhi							
Goa		1					1
Gujarat	5	9	13	5	1		33
Haryana			1	3	17		21
Himachal Pradesh	7	5					12
Jammu and Kashmir	17	4	1				22
Jharkhand	12	12					24
Karnataka	1	5	8	14	2		30
Kerala				4	10		14
Madhya Pradesh	1	15	12	19	4		51
Maharashtra	5	13	10	5	1	2	36
Manipur	5		1	3			9
Meghalaya	9	2					11
Mizoram	8						8
Nagaland	8	2		1			11
Odisha	2	12	11	4	1		30
Puducherry		1	1	1			3
Punjab					22		22
Rajasthan	7	8	15	3			33
Sikkim	3	1					4
Tamil Nadu		5	14	7	5	1	32
Telangana		3	1	5		1	10
Tripura		1					1
Uttar Pradesh		6	5	23	41		75
Uttarakhand	11				2		13
West Bengal	1		3	1	14	1	20

Demarcation of Classes:

Very Low- < Rs. 1616	Low – Rs. 1616 to Rs.3303	Medium – Rs. 3303 to Rs. 5192
High – Rs. 5192 to 8701	Very High – Rs. 8701 to Rs. 29260	

Figure 5.3: India's LULC Map and quintile distribution of Cropland Ecosystem Services

Land Use and Land Cover	**2014-15**
	
2011-12	**2005-06**
	

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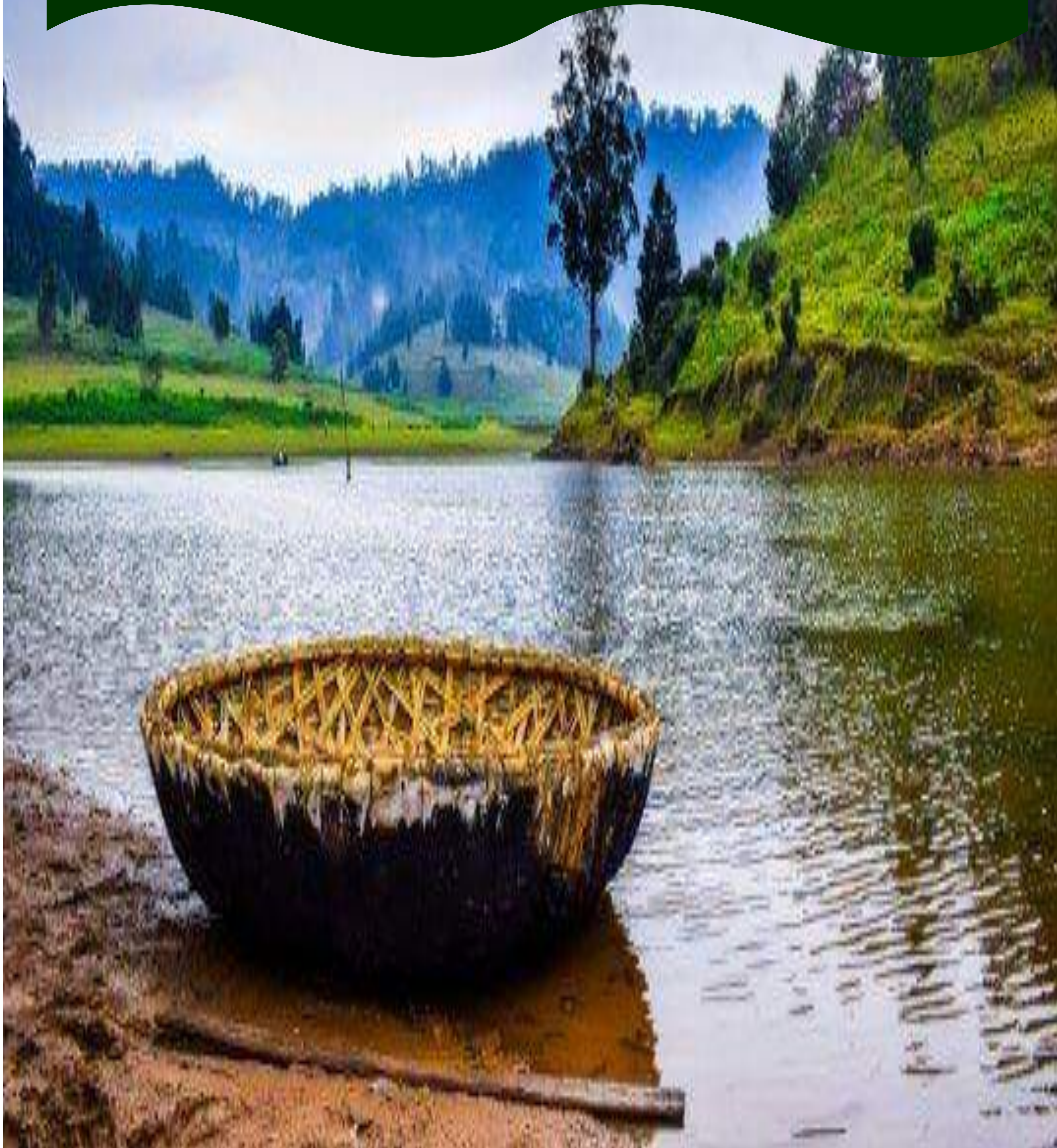
Valuation of Nature – Based Tourism



Chapter 6

Valuation of Nature-Based Tourism

Travelling a thousand miles of the world is better than reading a thousand scrolls

A Chinese Proverb

Introduction

The term "Tourism" is used to refer to travel for recreational, leisure or business purposes. The World Tourism Organization defines tourists as people "traveling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes". Tourism has become a popular global leisure activity and is a vital economic activity for some countries. It was recognized in the Manila Declaration on World Tourism of 1980 as "an activity essential to the life of nations because of its direct effects on the social, cultural, educational, and economic sectors of national societies and on their international relations." Tourism brings in large amounts of income in payment for goods and services available, accounting for 30% of the world's exports of services and 6% of overall exports of goods and services. It also creates opportunities for employment in the service sector of the economy, associated with tourism. These service industries include transportation services, such as airlines, cruise ships and taxicabs; hospitality services including hotels and resorts; and entertainment venues, such as amusement parks, casinos, shopping malls, music venues and theatres.

2. Tourism also has the potential to create beneficial effects on the environment by contributing to environmental protection and conservation. It is a way to raise awareness of environmental values and it can serve as a tool to finance protection of natural areas and increase their economic importance. Tourism at many of the world's nature 'hotspots' contributes significantly to gross domestic product (GDP) in the host countries.

3. India is a very sought-after tourist destination with an average of 18.75 million Foreign Tourist Visits per annum during 2008-2015, with a corresponding number of 6.48 million International Tourist Arrivals per annum during the same period. Domestic tourism sector is also significant, with the number of domestic tourist visits in India during 2008-2015 averaging about 968.30 million per annum. The Foreign Exchange Earnings

from tourism in India in 2015 was Rs. 1,34,844 crore as compared to Rs. 51,294 crore in 2008 registering an average growth of 15.4% during the period.

4. The top 5 States in domestic tourist visits in 2015 were Tamil Nadu (333.5 million), Uttar Pradesh (204.9 million), Andhra Pradesh (121.6 million), Karnataka (119.9 million) and Maharashtra (103.4 million) with their respective shares being 23.3%, 14.3%, 8.5%, 8.4% and 7.2% whereas in 2017 the number of domestic tourist visits increased and the top 5 States were Tamil Nadu (345.1 million), Uttar Pradesh (234 million), Karnataka (180 million), Andhra Pradesh (165.4 million) and Maharashtra(119.2 million) with their respective shares being 20.9%, 14.2%, 10.9%, 10.0% and 7.2%.

5. In respect of foreign tourist visits in 2015, the top 5 States/ UTs were Tamil Nadu (4.7 million), Maharashtra (4.4 million), Uttar Pradesh (3.1 million), Delhi (2.4 million) and West Bengal (1.5 million) whereas in 2017, the top 5 States/ UTs were Maharashtra (5.1) million, Tamil Nadu (4.9 million), Uttar Pradesh (3.6 million), Delhi (2.7 million) and Rajasthan (1.6 million).

6. Nature-based tourism can be said to India's forte, with the country's varied topographical features ranging from the snow-capped mountains to exquisite backwaters offering a lifetime opportunity not only to enjoy the natural splendour but also to indulge in the various adventure activities such as mountaineering, jungle safari and fishing. India has not just the world's greatest biodiversity, but also one of the greatest adventure tourism assets in the world in the form of the Himalayas and its mighty rivers. Be it 'Nature Tourism' based on the web of life or life forms, or 'Adventure Tourism' dealing with sports activities in various natural environs or even - all of these activities in India can be said to conform to the definition of "nature-based tourism". The angling and fishing tours in the charming Himalayan valleys and coastal stretches of the Arabian Sea and Bay of Bengal, the mountain tours offering a range of adventure activities such as skiing, trekking, rock climbing and hiking in the snow-clad peaks, the soothing backwater tours presenting sylvan surroundings endowed with palm-groves and swaying paddy fields or the wildlife tours across sanctuaries and national parks which are the repository of an amazing variety of flora and fauna – tourists can be spoilt for choice in their ventures to be up and close with nature.

7. 'Religious Tourism', where the tourist travels to achieve faith, religion or spiritual fulfilment can also be brought under the ambit of "nature-based tourism", what with most religious sites surrounded with all types of natural features including mountains, hills, forests, groves, rivers, lakes, lagoons, caves, islands and springs. This seems to be in line with the fact that most religions have mythology, cosmology, theology or ethics related to

earth, nature and land, setting out the relationship to the natural world and the responsibility of human beings towards the planet.

8. Some major tourist destinations across the States of India are highlighted in the following paragraphs:

i. Western Ghats are counted among the top 18 biodiversity hotspots in the world and boast of quite a few endangered wildlife species. Hill stations amidst the rain forests, valleys, eco-trails, plantations, backwaters and the unique biological settings and the infinite gardens of Karnataka and Kerala make it a perfect ecotourism destination.

ii. The North Eastern States – The seclude calm environs of Assam, the multitude of cultural diversity and secluded wonders of Meghalaya, the diverse topography and unexplored terrains of Arunachal Pradesh are some of the examples which make the north-eastern states a popular destination for ecotourism in India.

iii. Himalayan States of Uttarakhand and Himachal Pradesh, as also Ladakh with their snow-capped mountains, rolling meadows, high altitude lakes, dense forests, rich biodiversity and ancient temples and monasteries have been on top of every traveller's bucket list.

iv. The 7,517 km-long coastline of India is home to some of the best beaches in the world including the internationally favourite beaches of Goa, Kerala and Andaman & Nicobar Islands. The black, golden and white sandy beaches of Indian Coastline offer a wide range

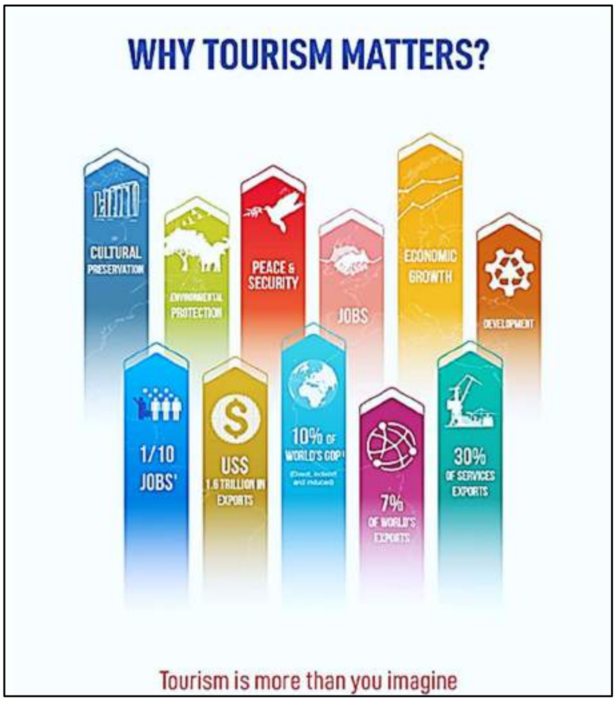
of opportunities from rejuvenation to adventure water sports include canoeing, catamaran, scuba diving and snorkelling.

v. The Great Indian Thar Desert is a subtropical desert land located in the north-western part of Indian subcontinent, surrounded by the salt marsh known as the Great Rann of Kutch, the Aravalli Ranges and by Indus and Sutlej Rivers. The diversified habitat and beautiful ecosystem of the Thar desert is home to some endangered species of wild animals, which are vanishing in other parts of the country. The colourful culture of Thar desert reflected in the folk music and dance of tribes, their traditional dresses and jewellery and the majestic heritage forts against the backdrop of the golden sand dunes are the attraction of the region.

vi. River Ganga is worshipped and venerated as Goddess in Hindu religion and Ganga has been at the centre of social, cultural and religious life of the people, especially in North India. But religion apart, locations on the Gangetic trail, right from its source at Gangotri glacier, to the cities of Haridwar, Rishikesh and Allahabad, offer stunning views to the travellers and several opportunities to experience traditional Indian festivals that are held at its banks. At Devprayag, a small town situated in the rugged terrains of the Himalayas in Uttarakhand, one can witness the confluence of the rivers Bhagirathi and Alakananda which merge to form the Ganges, with the highlight being the splendid sight of the differently coloured waters of the two rivers. At Rishikesh, the fast flowing emerald Ganga helps adventure buffs to enjoy activities like river rafting, kayaking, and body surfing. Gangasagar, that is located just before Ganga converges with the Bay of Bengal, offers the charms of an un-spoilt beach on the estuary of the river Ganges, offering acres of silver sand and clear blue sky, and the calm sea for visitors who would like to spend some time in tranquillity.

Tourism to Sustainable tourism

9. Recognising the fact that tourism is one of the most dynamic economic sectors with a wide range of upstream and downstream effects on other economic activities, thanks to a very large and diversified supply chain and its ability to create decent jobs and generate trade opportunities, it finds a mention in the outcome document of the United Nations Conference on Sustainable Development, entitled "The future we want". Paragraph 130 of The Future We Want mentions that Member States recognize "the need to support ***sustainable*** tourism activities and relevant capacity-building that promote environmental awareness, conserve and protect the environment, respect wildlife, flora, biodiversity, ecosystems and cultural diversity, and improve the welfare and livelihoods of local communities". More specifically, Member States, through paragraph 131, "encourage the promotion of investment in sustainable tourism, including eco-tourism and cultural tourism, which may include creating small and medium sized enterprises and facilitating access to finance, including through microcredit initiatives for the poor, indigenous peoples and local communities in areas with high eco-tourism potential".



10. Since preservation of environment is one of the main drivers of tourism, sustainable tourism development takes into account current and future economic, social and environmental impacts, while addressing the needs of visitors, the industry, the host communities and most importantly, environment.

11. Subsequently, with the advent of the 2030 Agenda for sustainable development, the UN World Tourism Organization (UNWTO) published a two-volume report titled, 'Tourism for Development,' that makes recommendations on the ways in which tourism could contribute to sustainable development and the SDGs, and illustrates the global reach and positive effects of tourism on other sectors. The publication highlights the need to integrate sustainability into tourism policies, business practices and tourist behaviour. Describing tourism as a driver of sustainable development, the report explains that

tourism benefits economic growth, quality of life, environmental protection, diverse cultural heritage and world peace.

12. The report also stresses on the importance of devising and implementing sustainable tourism policies (SDG target 8.9), developing and implementing tools to monitor impacts for sustainable tourism (SDG target 12.b) and increasing the economic benefits from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism (SDG target 14.7).

13. In line with the adage, "what gets measured, gets managed", a pre-requisite for devising any sustainable tourism policy or monitoring impacts for sustainable tourism, is an assessment of the current flow of tourism services, especially that of nature-based tourism or eco-tourism. In this context, an effort has been made in this chapter to estimate the "value of nature-based tourism services" in the States of India.

14. A conservative estimate of this value can be derived using a direct expenditure method using the information on average expenditure per person/day on a trip, the duration of stay, number of total visitors, total visitor expenditure (average expenditure per person/day x average length of stay x total visitor numbers) and the attribution factor (expenditure that can be directly attributed to the natural areas). It should be noted that the direct expenditure method provides only a conservative minimum estimate of the total economic contribution of natural areas as it excludes secondary expenditure such as local employment and does not include wider values (such as use values, like ecosystem services and future values, or non-use values, like biodiversity and ritual values). In short, there is likely to be other levels of benefit of natural areas additional to the direct expenditure noted here. However, the secondary expenditure could be calculated from the direct expenditure data through a form of multiplier analysis.

Sources of data for valuation of 'nature-based tourism' services

15. The annual publication, India Tourism Statistics, published by the Ministry of Tourism gives the annual number (calendar year-wise) of Domestic and Foreign Travel Visits by state of destination. State-level detailed information on tourism is available in the State Tourism Surveys which includes information on important tourist destinations and various characteristics of the tourist.

16. The National Sample Survey Office has conducted two focussed household surveys on Domestic Tourism, one during July 2008 to June 2009 (65^{th} Round) and the other during July 2014 to June 2015 (72^{nd} round). The surveys provide a detailed insight into several characteristics of Domestic Tourists - duration of stay, origin and destination, mode of

transport, accommodation type, purpose of visit, expenditure on various components of the trip, household income, as also age and gender of tourists.

17. The Survey collected information on both one-day trips and overnight trips. Since WTO 2008 recognizes tourism as visits to a recreation site involving at least one overnight stay, only the overnight trips were considered for the purpose of this valuation. An overnight trip is defined in the survey as a movement of not less than two consecutive calendar days and of not more than 6 months, by one or more household members outside their usual environment (which includes the usual place of residence (UPR)) and return to the same UPR (a round trip), irrespective of place of stay. The movement should be for any of the following purposes:

i. Business: This category includes trips of employees of organisations or of self-employed people, trips for installation of equipment, inspection, purchase and sale for enterprise; for attending conferences, congresses, trade fairs and exhibitions; for delivering lectures or concerts; for participation in professional sport activities, etc.
ii. Holidaying, leisure & recreation: This category includes sightseeing, attending sporting and cultural events, adventure sports, recreational activities, cultural activities, holidays at beaches and hill stations, etc.
iii. Social: This category includes visiting friends and relatives, attending marriages / any other family events / other social functions, etc.
iv. Pilgrimage & Religious: This category includes attending various religious meetings and events, and undertaking pilgrimages to different places of worship or holy places.
v. Education and Training: This category includes trips to join short-term residential educational courses (up to six months), education and research programmes, acquiring specific skills through formal on-the-job training including paid study, etc.
vi. Health and Medical: This category includes trips to spa, fitness and health resorts, treatments and cures, ayurvedic and other health resorts of traditional medicines, etc., for getting short-term (up to six months) medical treatment.
vii. Shopping: This category includes purchasing of consumer goods for own personal use or as gifts but not for resale or for use in a future productive process (in which case the purpose would be business).
viii. Others: This category includes purposes which are not indicated elsewhere. For example, making a trip to render some social service, such as for relief work after natural calamities etc. will come under this category.

For compiling estimates of 'nature-based tourism services', only the visits with 'holidaying, leisure and recreation' and 'pilgrimage and religion' as the main purpose of the visit have been considered.

18. In respect of expenditure incurred on the trip, the survey provides information on all expenditure in connection with the trip, except those to be used / intended to be used for resale or for productive purposes / enterprises and includes the expenditure which is already paid or payable in future, irrespective of the source of expenditure. Information is available on the expenditure incurred on account of accommodation, 'food & drink', transport and 'recreation, religious, cultural & sporting and health related activities'. Expenditure made for 'shopping' or purchase of any consumer good for own consumption or for gifts but not for resale or for use in a future productive process is also captured by the survey. However, this component is inclusive of expenditure incurred during or after the trip on items like bags, electronic equipment and photographic equipment, and even items of high unit value like cars, computers, etc. related to a trip if those are used for consumption purpose and not for productive purpose. Therefore, this component has been excluded while calculating the average expenditure for the trip.

19. In a nutshell, the value of 'nature-based tourism services' has been estimated as the product of:

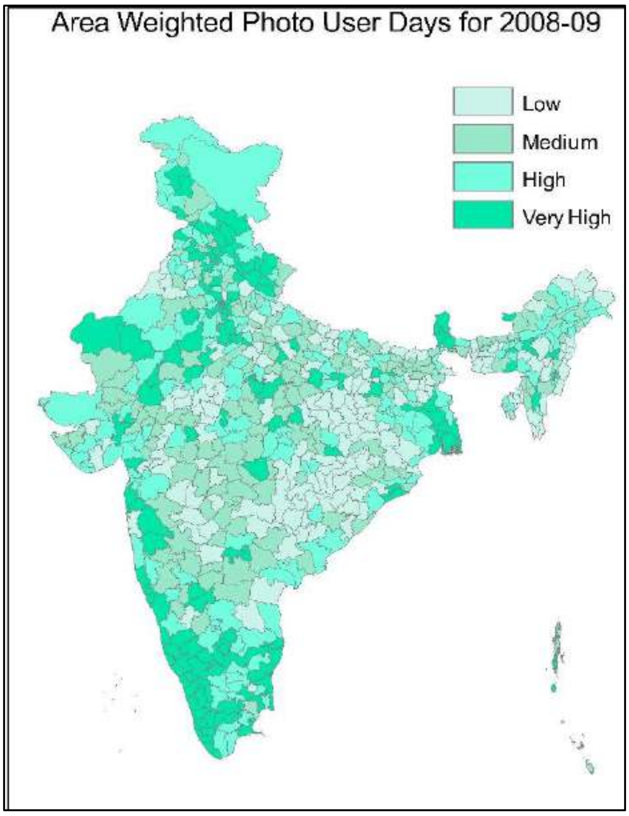
1. average expenditure (excluding shopping) incurred per person by the tourists having 'holidaying, leisure and recreation' and 'pilgrimage and religion' as the main purpose of visit by state of destination as derived from the Domestic Tourism Survey;
2. the proportion of tourists with 'holidaying, leisure and recreation' and 'pilgrimage and religion' as the main purpose of visit by state of destination as derived from the Domestic Tourism Survey;
3. total number of Domestic and Foreign Tourist Visits by state of destination as given in the publication 'Indian Tourism Statistics'

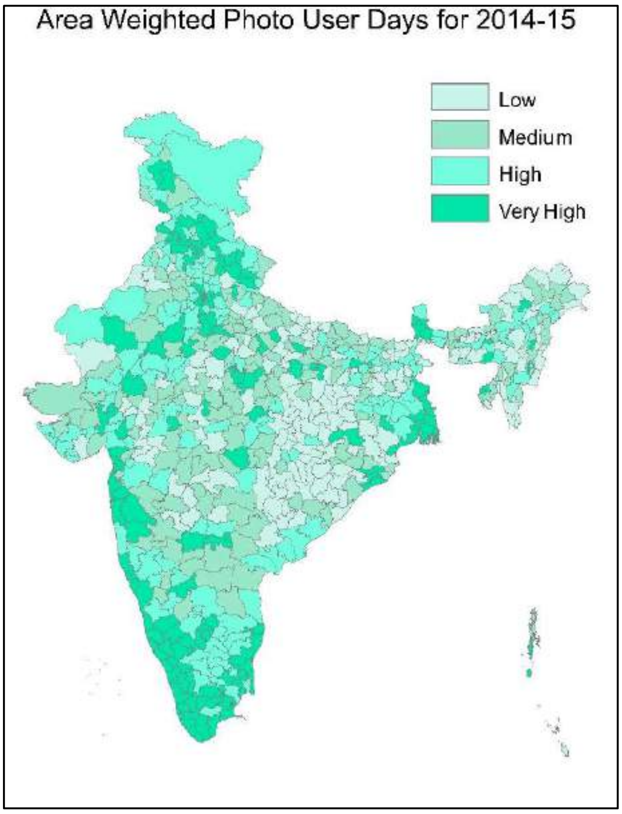
20. Estimates of the value of nature-based tourism services have been derived for the years 2008-09 and 2014-15 and are given in **Table 6.1**. Since the information in the publication, "Indian Tourism Statistics" is given on a calendar year basis, the average number of visits for the two relevant calendar years has been used for the compilation.

Table 6.1: Status of Nature based tourism in India

State/ UT	Total Visitors (in '000)		Visitors (in '000)		Nature based Tourism Expenditure per person (in Rs.)		Value of Service per sq. km (in '00 Rs.)	
	2008-09	2014-15	2008-09	2014-15	2008-09	2014-15	2008-09	2014-15
A & N Islands	146	307	136	204	10241	24064	1690	5956
Andhra Pradesh	145880	191159	80828	43746	863	1787	2536	2841
Arunachal Pradesh	176	349	69	202	1792	8250	15	199
Assam	3749	5182	415	1107	1608	2330	85	329
Bihar	14221	26163	1795	7767	1860	2203	355	1817
Chhattisgarh	479	21415	89	4864	593	828	4	298
Goa	2438	4678	1535	4123	2656	8228	11013	91632
Gujarat	15814	33861	3158	13154	902	1867	145	1253
Haryana	6303	7740	473	1864	825	1110	88	468
Himachal Pradesh	10593	16923	6552	9973	1717	5502	2021	9856
Jammu & Kashmir	8492	9364	5651	5075	2571	6898	654	1575
Jharkhand	6830	33415	2726	11014	817	756	279	1045
Karnataka	23000	119673	6387	37285	1315	3237	438	6294
Kerala	8264	13031	2994	2489	2111	6463	1626	4139
Madhya Pradesh	22824	71164	3524	18022	744	1008	85	589
Maharashtra	27833	102417	8841	54535	1588	1394	456	2470
Manipur	119	134	3	31	387	1859	0	26
Meghalaya	575	742	205	343	1367	1794	125	274
Mizoram	57	68	38	16	47483	3331	852	26
Nagaland	35	64	1	15	1539	1893	1	17
Odisha	6670	11358	2345	4746	2547	1145	384	349
Puducherry	897	1337	152	488	1161	3219	3587	31900
Punjab	2998	25283	410	12978	803	1080	65	2782
Rajasthan	28234	35632	10769	12317	1119	2722	352	980
Sikkim	510	678	340	586	8648	10512	4150	8680
Tamil Nadu	109220	335178	42961	119336	1221	1953	4033	17921
Tripura	285	393	27	82	7743	706	200	55
Uttar Pradesh	131418	196861	30023	58131	4364	1071	5438	2585
Uttarakhand	21344	25848	16150	17037	839	2933	2532	9343
West Bengal	21079	61044	3457	16318	2002	2192	780	4031

21. To give an idea about the variations across districts, the possibility of using some of the global assessments of this ecosystem service was explored. The InVEST project of the Stanford University is one such tool, which provides a suite of free, open-source software models that can be used to map and value the goods and services from nature that sustain and fulfill human life. To quantify the value of natural environment in tourism, the InVEST recreation model[39] predicts the spread of person-days of recreation, based on the locations of natural habitats and other features that factor into people's decisions about where to recreate. The tool estimates the contribution of each attribute to visitation rate in a simple linear regression. In the absence of empirical data on visitation, the model is parametrized using a proxy for visitation: geotagged photographs posted to the website '***flickr***'. Using photo-user-day estimates, the model provides outputs maps showing current patterns of recreational use in absolute terms and as per unit of geographic area. This tool was used to get the district-wise maps for the years 2008-09 and 2014-15, which could then be compared with the compiled estimates.





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[39] http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/recreation.html

Statement 2.1: State-wise Soil Nutrient Indices, by macro and micro nutrients, Cycle I (2015-2017)

(As on 5.9.2019)

S.No.	States / UT's	Macro Nutrients				Micro Nutrients					
		Nitrogen (N)	Phosphorus (P)	Potassium (K)	Organic Carbon (OC)	Boron (B)	Copper (Cu)	Iron (Fe)	Manganese (Mn)	Sulphur (S)	Zinc (Zn)
1	Andaman and Nicobar Islands	1.01	1.08	1.16	1.32	1.97	1.96	1.98	1.99	1.01	1.76
2	Andhra Pradesh	1.07	2.47	1.96	2.00	1.52	1.93	1.67	1.88	1.84	1.59
3	Arunachal Pradesh	2.72	1.15	2.02	2.74	1.24	1.77	1.93	1.76	1.81	1.57
4	Assam	1.91	1.36	1.29	2.32	1.20	1.94	1.96	1.96	1.90	1.93
5	Bihar	1.29	1.79	1.75	1.87	1.00	1.25	1.23	1.23	1.00	1.15
6	Chhattisgarh	1.31	1.87	2.06	1.75	1.59	1.95	1.86	1.92	1.74	1.62
7	Dadra and Nagar Haveli	0.00	1.36	2.86	1.82	2.00	2.00	1.92	2.00	2.00	1.89
8	Delhi	1.22	1.50	2.07	1.40	1.75	1.88	1.60	1.67	2.00	1.86
9	Goa	1.91	1.31	2.06	2.72	1.52	1.98	1.99	1.99	1.69	1.80
10	Gujarat	1.00	2.01	2.31	1.83	1.33	1.85	1.51	1.84	1.42	1.41
11	Haryana	1.00	1.22	1.89	1.04	1.85	1.91	1.69	1.75	1.92	1.78
12	Himachal Pradesh	1.59	2.10	2.20	2.67	1.90	1.94	1.89	1.71	1.97	1.89
13	Jammu and Kashmir	1.94	1.59	1.73	2.31	1.41	1.76	1.65	1.51	1.66	1.56
14	Jharkhand	1.50	1.45	1.76	1.94	1.67	1.94	1.91	1.92	1.60	1.66
15	Karnataka	1.62	1.97	2.16	1.76	1.54	1.92	1.49	1.82	1.65	1.46
16	Kerala	1.02	1.84	1.87	2.41	1.46	1.95	1.96	1.90	1.52	1.89
17	Madhya Pradesh	1.25	1.43	2.28	1.91	1.68	1.93	1.74	1.89	1.69	1.57
18	Maharashtra	1.63	1.92	2.56	1.66	1.24	1.97	1.38	1.89	1.24	1.50
19	Manipur	1.02	1.45	1.18	2.26	1.97	1.83	1.33	1.42	1.80	1.71
20	Meghalaya	1.25	1.23	1.38	2.72	1.12	1.90	1.66	1.70	1.38	1.76
21	Mizoram	1.88	1.05	1.86	1.56	1.67	2.00	1.94	1.99	1.68	1.93
22	Nagaland	2.48	1.19	1.93	2.87	1.77	1.57	1.86	1.73	1.94	1.61
23	Odisha	1.24	1.38	1.76	1.56	1.34	1.55	1.62	1.51	1.45	1.53
24	Puducherry	1.01	1.12	1.89	0.00	1.00	1.97	1.82	1.91	2.00	1.90
25	Punjab	1.27	1.39	1.95	1.10	1.22	1.99	1.89	1.58	1.92	1.91
26	Rajasthan	1.00	1.86	2.18	1.23	1.00	1.94	1.49	1.89	1.52	1.56
27	Sikkim	1.77	1.67	2.29	2.98	1.64	1.72	1.95	1.67	1.79	1.75
28	Tamil Nadu	1.02	1.79	1.91	1.26	1.38	1.96	1.67	1.80	1.63	1.72
29	Telangana	1.31	1.54	1.98	1.22	1.09	1.11	1.06	1.09	1.10	1.08
30	Tripura	1.93	1.66	1.25	2.18	1.89	1.97	1.93	1.97	1.62	1.89
31	Uttar Pradesh	1.02	1.10	1.82	1.15	1.64	1.95	1.76	1.88	1.63	1.71
32	Uttarakhand	1.02	1.95	1.81	1.79	1.07	1.90	1.86	1.87	1.71	1.77
33	West Bengal	1.54	2.63	2.07	1.77	1.28	1.97	1.94	1.77	1.38	1.52

Statement 2.2: State-wise Soil Nutrient Indices, by macro and micro nutrients, Cycle II (2017-2019)

(As on 5.9.2019)

S.No.	States / UT's	Macro Nutrients				Micro Nutrients					
		Nitrogen (N)	Phosphorus (P)	Potassium (K)	Organic Carbon (OC)	Boron (B)	Copper (Cu)	Iron (Fe)	Manganese (Mn)	Sulphur (S)	Zinc (Zn)
1	Andaman and Nicobar Islands	1.01	1.02	1.03	1.15	1.96	1.84	2.00	1.99	1.00	1.85
2	Andhra Pradesh	1.25	2.49	2.40	1.70	1.83	1.95	1.72	1.90	1.89	1.64
3	Arunachal Pradesh	2.96	1.02	1.17	2.97	1.06	1.81	1.98	1.74	1.11	1.59
4	Assam	1.86	1.15	1.24	1.96	1.04	2.00	2.00	1.94	1.97	1.92
5	Bihar	1.03	1.88	1.88	2.00	1.57	1.94	1.56	1.83	1.71	1.94
6	Chhattisgarh	1.25	1.82	2.21	1.70	1.70	1.96	1.90	1.97	1.64	1.56
7	Dadra and Nagar Haveli	1.27	1.44	2.79	1.88	2.00	2.00	1.99	2.00	2.00	1.93
8	Daman and Diu	1.01	1.23	1.93	1.96	1.37	1.92	1.75	1.89	1.95	1.84
9	Delhi	1.72	1.11	2.34	2.10	1.85	1.99	1.93	1.88	1.77	1.99
10	Goa	1.85	1.48	1.99	2.59	1.45	1.98	2.00	1.99	1.26	1.84
11	Gujarat	1.35	2.12	2.38	1.92	1.50	1.94	1.75	1.95	1.78	1.69
12	Haryana	1.00	1.24	2.00	1.09	1.57	1.96	1.64	1.61	1.92	1.71
13	Himachal Pradesh	1.64	2.12	2.22	2.57	1.95	1.97	1.90	1.80	1.85	1.90
14	Jammu and Kashmir	2.00	1.54	1.79	2.41	1.74	1.79	1.68	1.56	1.63	1.66
15	Jharkhand	1.46	1.45	1.75	2.02	1.76	1.93	1.91	1.87	1.70	1.71
16	Karnataka	1.57	1.89	2.16	1.77	1.45	1.92	1.46	1.83	1.63	1.38
17	Kerala	1.02	1.81	1.93	2.43	1.53	1.97	1.98	1.95	1.65	1.93
18	Madhya Pradesh	1.25	1.44	2.19	1.95	1.72	1.94	1.79	1.91	1.76	1.59
19	Maharashtra	1.39	2.04	2.57	1.68	1.54	1.97	1.34	1.86	1.46	1.47
20	Manipur	1.33	1.55	1.78	2.88	1.47	1.80	1.96	1.97	1.43	1.49
21	Meghalaya	1.31	1.21	1.45	2.73	1.79	1.87	1.92	1.64	1.54	1.63
22	Mizoram	1.89	1.03	1.93	1.59	2.00	0.00	2.00	0.00	2.00	2.00
23	Nagaland	2.72	1.14	1.91	2.78	1.98	1.95	2.00	1.94	1.98	1.66
24	Odisha	1.22	1.35	1.83	1.54	1.32	1.44	1.48	1.34	1.43	1.51
25	Puducherry	1.01	1.28	2.20	2.50	1.01	1.99	1.89	1.98	2.00	1.91
26	Punjab	1.13	1.55	2.02	1.32	1.35	1.99	1.89	1.54	1.85	1.86
27	Rajasthan	1.00	1.80	2.10	1.19	1.00	1.95	1.48	1.92	1.84	1.49
28	Sikkim	1.27	2.24	2.17	2.93	1.56	1.91	1.94	1.95	1.93	1.72
29	Tamil Nadu	1.03	1.90	2.23	1.22	1.45	1.96	1.66	1.76	1.63	1.70
30	Telangana	1.21	2.20	2.17	1.66	1.76	1.90	1.56	1.78	1.80	1.60
31	Tripura	1.46	1.71	1.37	1.74	1.82	1.99	1.99	1.98	1.95	1.80
32	Uttar Pradesh	1.02	1.16	1.79	1.13	1.64	1.96	1.74	1.84	1.63	1.70
33	Uttarakhand	1.13	2.02	1.94	1.89	1.49	1.89	1.84	1.82	1.75	1.81
34	West Bengal	1.70	2.69	1.69	2.39	1.83	1.99	2.00	1.96	1.24	1.95

Statement 3.1: Water Quality Accounts for Godavari River Basin, Site-wise and Month-wise, for the year 2015-16

SRU (in millions)

Site	Month	B	C	D	E	U	Grand Total
Ashti		**66678**	**2308**	**991253**		**7363**	**1067603**
	January		1704				1704
	February					4304	4304
	March					1215	1215
	April		604				604
	May					1359	1359
	June					485	485
	July			74953			74953
	August			67908			67908
	September			799217			799217
	October			49175			49175
	November	59976					59976
	December	6702					6702
Bamni		**87863**	**15366**	**368453**	**12222**	**6965**	**490869**
	January		15366				15366
	February			17435			17435
	March				11358		11358
	April			1795			1795
	May				864		864
	June					6965	6965
	July	87863					87863
	August			37019			37019
	September			198037			198037
	October			70258			70258
	November			25807			25807
	December			18100			18100
Bhadrachalam				**45587**	**2337134**	**13081**	**2395802**
	January			18191			18191
	February					10038	10038
	March					1868	1868
	April					1176	1176
	May			1322			1322
	June				7033		7033
	July				347590		347590
	August				360267		360267
	September				1174274		1174274
	October				365755		365755
	November				82214		82214
	December			26074			26074
Bhatpalli		**7180**		**5520**		**1509**	**14209**
	January	530					530
	February			421			421
	March	711					711
	April	384					384
	May	371					371
	June					406	406

SRU (in millions)

Site	Month	B	C	D	E	U	Grand Total
	July	3941					3941
	August	1243					1243
	September			2097			2097
	October			2265			2265
	November					1104	1104
	December			736			736
Hivra		**28695**		**21207**		**24777**	**74679**
	January	1681					1681
	February	4599					4599
	March			4407			4407
	April	603					603
	May						
	June					11072	11072
	July					11661	11661
	August	18435					18435
	September			13358			13358
	October			3442			3442
	November					2044	2044
	December	3376					3376
Jagdalpur					**473097**		**473097**
	January						
	February						
	March						
	April						
	May						
	June						
	July				80673		80673
	August						
	September				326695		326695
	October				65730		65730
	November						
	December						
Keolori		**9636**	**1810**	**36414**			**47859**
	January		1810				1810
	February	1584					1584
	March			1118			1118
	April	991					991
	May						
	June						
	July	474					474
	August	4251					4251
	September			22177			22177
	October			13118			13118
	November	1038					1038
	December	1297					1297
Konta			**26454**	**138475**	**701993**	**33966**	**900888**
	January			30063			30063
	February					33966	33966

SRU (in millions)

Site	Month	B	C	D	E	U	Grand Total
	March			40269			40269
	April		26454				26454
	May			36415			36415
	June				29622		29622
	July				86857		86857
	August				57594		57594
	September				393543		393543
	October				91446		91446
	November				42931		42931
	December			31728			31728
Kopergaon					**955037**		**955037**
	January						
	February						
	March						
	April						
	May						
	June						
	July				22426		22426
	August				14451		14451
	September				592369		592369
	October						
	November				325792		325792
	December						
Kumhari		**24737**		**117096**			**141833**
	January	7091					7091
	February			4463			4463
	March	1427					1427
	April	480					480
	May	248					248
	June	496					496
	July			4137			4137
	August			2748			2748
	September			105747			105747
	October	4858					4858
	November	2597					2597
	December	7539					7539
Mancherial					**161442**	**41518**	**202960**
	January					10295	10295
	February					9739	9739
	March					7238	7238
	April					605	605
	May						
	June						
	July				35674		35674
	August				41089		41089
	September				32264		32264
	October				41340		41340
	November					13641	13641

SRU (in millions)

Site	Month	B	C	D	E	U	Grand Total
	December				11075		11075
Nandgaon		**3578**		**27559**	**105226**		**136363**
	January	1483					1483
	February			5423			5423
	March			1971			1971
	April						
	May						
	June						
	July	2096					2096
	August			4672			4672
	September				105226		105226
	October			4435			4435
	November			10192			10192
	December			866			866
Nowrangpur				**2283**	**42008**	**640**	**44930**
	January			926			926
	February					640	640
	March			493			493
	April			531			531
	May			333			333
	June				345		345
	July				2428		2428
	August				1424		1424
	September				29617		29617
	October				5563		5563
	November				1571		1571
	December				1059		1059
P.G.Bridge		**18160**	**71**	**6392**		**31974**	**56597**
	January		71				71
	February						
	March					54	54
	April						
	May						
	June					31920	31920
	July	10995					10995
	August	975					975
	September			6392			6392
	October	6102					6102
	November	88					88
	December						
Pachegaon					**83010**		**83010**
	January						
	February						
	March						
	April						
	May						
	June						
	July						

SRU (in millions)

Site	Month	B	C	D	E	U	Grand Total
	August						
	September						
	October						
	November				72996		72996
	December				10014		10014
Pathagudem			**862**	**848**	**708138**	**5348**	**715197**
	January					3537	3537
	February					1717	1717
	March			848			848
	April		862				862
	May					94	94
	June				14695		14695
	July				73538		73538
	August						
	September				502444		502444
	October				96983		96983
	November				13844		13844
	December				6635		6635
Pauni		**12285**		**85676**			**97961**
	January						
	February						
	March						
	April						
	May						
	June	1034					1034
	July	11251					11251
	August			44070			44070
	September			37796			37796
	October			3186			3186
	November			602			602
	December			22			22
Perur				**86311**	**3965498**	**26155**	**4077964**
	January			28334			28334
	February					18902	18902
	March			14817			14817
	April					7253	7253
	May			1378			1378
	June				14203		14203
	July				492972		492972
	August				477115		477115
	September				2331794		2331794
	October				539857		539857
	November				109557		109557
	December			41782			41782
Polavaram				**77179**	**3453208**	**119419**	**3649806**
	January					51612	51612
	February					39191	39191
	March			45246			45246

SRU (in millions)

Site	Month	B	C	D	E	U	Grand Total
	April					28616	28616
	May			31933			31933
	June				45992		45992
	July				594708		594708
	August				544942		544942
	September				1559969		1559969
	October				533952		533952
	November				106977		106977
	December				66666		66666
Rajegaon		**21031**		**190353**			**211384**
	January	2320					2320
	February	100					100
	March			660			660
	April						
	May						
	June						
	July	18611					18611
	August			14454			14454
	September			134407			134407
	October			27642			27642
	November			10001			10001
	December			3190			3190
Ramakona		**1564**	**113**	**36900**			**38578**
	January		113				113
	February	98					98
	March			51			51
	April						
	May						
	June						
	July	1269					1269
	August			16928			16928
	September			13534			13534
	October			4102			4102
	November			2285			2285
	December	197					197
Sakmur		**94071**		**164598**		**9310**	**267978**
	January	7210					7210
	February	7513					7513
	March			4509			4509
	April	1063					1063
	May						
	June					9310	9310
	July	54011					54011
	August			29108			29108
	September			82882			82882
	October			48098			48098
	November	17373					17373
	December	6900					6900

SRU (in millions)

Site	Month	B	C	D	E	U	Grand Total
Sangam				**718**	**25656**	**74**	**26448**
	January			174			174
	February					74	74
	March						
	April						
	May						
	June				8375		8375
	July				8141		8141
	August				492		492
	September				4615		4615
	October				3339		3339
	November				695		695
	December			543			543
Satrapur		**2347**		**29306**		**3416**	**35068**
	January	882					882
	February	690					690
	March			735			735
	April	287					287
	May			155			155
	June	489					489
	July			3479			3479
	August			5265			5265
	September			13293			13293
	October			4655			4655
	November					3416	3416
	December			1724			1724
Tekra		**785029**		**935064**		**10739**	**1730832**
	January	13559					13559
	February	14486					14486
	March	11605					11605
	April	6914					6914
	May	4013					4013
	June					10739	10739
	July	319876					319876
	August	175287					175287
	September			935064			935064
	October	146140					146140
	November	68369					68369
	December	24780					24780
Wairagarh		**1161**		**18538**			**19699**
	January						
	February						
	March						
	April						
	May						
	June						
	July	868					868
	August	293					293

SRU (in millions)

Site	Month	B	C	D	E	U	Grand Total
	September			15695			15695
	October			2284			2284
	November			542			542
	December			18			18
Grand Total		**1164017**	**46984**	**3385730**	**13023670**	**336253**	**17956653**

Statement 3.2: Water Quality Accounts for Groundwater in Punjab, 2015

(HaM)

Districts	Block	A	C	E	U	Grand Total
Amritsar			**36322**	**64816**	**22397**	**123534**
	Ajnala			14450	7225	21675
	Chogawan			15172	15172	30343
	Jandiala		15898			15898
	Rayya			19154		19154
	Tarsikka			16039		16039
	Verka		20424			20424
Barnala				**7402**	**54116**	**61518**
	Barnala				23060	23060
	Mehal Kalan			7402	7402	14804
	Sehna				23654	23654
Bathinda			**4263**	**60443**	**65606**	**130312**
	Bathinda		4263	21315	8526	34105
	Nathana				21993	21993
	Phul			7502	11253	18756
	Rampura			6321	18962	25282
	Sangat			15561		15561
	Talwandi Sabo			9744	4872	14616
Faridkot			**2309**	**12588**	**46557**	**61453**
	Faridkot		2309	9235	23088	34632
	Kotkapura			3353	23468	26821
Fatehgarh Sahib				**39188**	**9608**	**48796**
	Amloh			12988		12988
	Bassi Pathana			4824	4824	9649
	Khera			4783	4783	9567
	Sirhand			16593		16593
Fazilka			**13374**	**36871**	**43079**	**93323**
	Abohar			7433	22299	29733
	Fazilka		13374		13374	26747
	Jalalabad			22032		22032
	Khuiyan Sarwar			7406	7406	14811
Firozpur				**32510**	**61964**	**94473**
	Gahll Kurd				28126	28126
	Guru Harsahai			5342	21369	26711
	Makhu			14699		14699
	Mamdot			12469	12469	24938
Gurdaspur		**5996**	**42901**	**97967**		**146863**
	Dera Baba Nanak			17691		17691
	Dhariwal		9632	9632		19263
	Dina Nagar			11139		11139
	Fatehgarh Churian		9325	9325		18649
	Gurdaspur		18808			18808
	Kahnuwan			20554		20554
	Kalanaur			13360		13360
	Quadian	5996		5996		11991
	Sri Hargobindpur		5136	10272		15407

(HaM)

Districts	Block	A	C	E	U	Grand Total
Hoshiarpur		**25531**	**7660**	**48274**		**81466**
	Bhunga	5130		5130		10259
	Dasuya	8544		4272		12816
	Garh Shankar			13128		13128
	Hazipur	2072	4144	2072		8289
	Hoshiarpur-I			9862		9862
	Hoshiarpur-Ii	2990		5981		8971
	Mahilpur		3516	3516		7032
	Mukerian	5498		3665		9163
	Talwara	1297		648		1945
Jalandhar		**12938**	**30220**	**67730**	**36619**	**147506**
	Adampur		5642	5642		11285
	Bhogpur			10591		10591
	Jalandhar				27278	27278
	Jalandhar East			9538		9538
	Jalandhar West	8870	8870			17740
	Nakodar			19066		19066
	Nurmahal		15707			15707
	Phillaur			17620		17620
	Rurka Kalan			5273	5273	10546
	Shahkot	4068			4068	8136
Kapurthala		**18345**		**29033**	**13294**	**60672**
	Kapurthala			15452		15452
	Nadala	11698				11698
	Phagwara			13580		13580
	Sultanpur Lodhi	6647			13294	19941
Ludhiana		**15156**	**21205**	**80945**	**50401**	**167707**
	Dehlon				18751	18751
	Doraha			27298		27298
	Jagraon				22502	22502
	Khanna			16238		16238
	Ludhiana			12503		12503
	Macchiwara			19830	6610	26440
	Pakhowal	12618				12618
	Samrala	2538		5076	2538	10152
	Sidhwan bet		21205			21205
Mansa				**70928**	**20645**	**91574**
	Bhikhi			21455		21455
	Budhlada			25192		25192
	Jhunir			8504	12756	21260
	Mansa			15778	7889	23667
Moga			**26313**	**28805**	**61452**	**116570**
	Bagha Purana			18962	18962	37924
	Dharmkot (Kot Isa Khan)		26313			26313
	Moga I			9843	9843	19686
	Moga Ii				14932	14932
	Nihal Singh Wala				17714	17714
Muktsar			**8279**	**34952**	**17775**	**61006**
	Lambi			20708		20708
	Malout		8279		8279	16558
	Muktsar			14244	9496	23741

(HaM)

Districts	Block	A	C	E	U	Grand Total
Nawanshahr		**15886**	**17436**	**23561**		**56883**
	Aur		14598			14598
	Balachaur	15886				15886
	Nawanshahr			23561		23561
	Saroya		2837			2837
Pathankot		**1454**	**4380**	**26125**		**31959**
	Bamial			1698		1698
	Dharkalan		1473	4418		5890
	Narot Jaimal Singh	1454	2908	1454		5815
	Pathankot			18555		18555
Patiala			**9577**	**67812**	**59862**	**137251**
	Bhunerheri				18108	18108
	Ghanour				15379	15379
	Nabha			32355	8089	40444
	Patiala		9577		9577	19153
	Patran			15986		15986
	Rajpura			5806	8709	14516
	Samana			13665		13665
Ropar		**9458**	**3807**	**25694**	**2988**	**41947**
	Anandpur Sahib		3807	3807		7615
	Chamkaur Sahib			9441		9441
	Morinda			2988	2988	5976
	Nurpur Bedi	2364		2364		4728
	Ropar	7094		7094		14188
Sangrur			**2365**	**75714**	**63893**	**141972**
	Andana				12328	12328
	Bhwanigarh			18285		18285
	Dhuri		2365	4729	4729	11823
	Lehragaga				15196	15196
	Maler Kotla			21671	10836	32507
	Sangrur				20806	20806
	Sunam			31029		31029
Sas Nagar			**4221**	**9900**	**8442**	**22563**
	Dera Bassi		1893	7572	3786	13250
	Kharar		2328	2328	4656	9312
Tarn Taran			**52921**	**33626**	**54473**	**141020**
	Bhikhiwind				17673	17673
	Chohla Sahib		16175			16175
	Gandiwind		26771			26771
	Khadur Sahib			17541		17541
	Naushehra Pannua		9975			9975
	Patti			16085		16085
	Tarn Taran				22192	22192
	Valtoha				14608	14608
Grand Total		**104764**	**287551**	**974884**	**693169**	**2060369**

Statement 3.3: Water Quality Accounts for Groundwater in Haryana, 2015

(HaM)

District	Block	A	C	E	U	Grand Total
Ambala			**1556**	**7408**	**30688**	**39652**
	Ambala			4296	17184	21480
	Barara		1556	3112	3112	7780
	Naraingarh				10392	10392
Bhiwani			**6691**	**31092**	**22250**	**60032**
	Badhra				4507	4507
	Bawani Khera		3001	3001	3001	9003
	Bhiwani		1743	6973	3486	12202
	Dadri		1946	9732	1946	13625
	Kairu			3334	1111	4445
	Loharu				3404	3404
	Siwani			1198	4794	5992
	Tosham			6854		6854
Faridabad			**1566**	**6222**	**9353**	**17141**
	Ballabgarh		1566	1566	4697	7829
	Faridabad			4656	4656	9312
Fatehabad				**18577**	**10217**	**28794**
	Bhattu Kalan			2916	2916	5832
	Bhuna				7301	7301
	Tohana			15661		15661
Gurgaon		**5307**	**2242**	**6545**	**9733**	**23827**
	Farukhnagar		744	1487	1487	3718
	Gurgaon	1250		2499	3749	7498
	Pataudi	1499	1499		4496	7494
	Sohna	2559		2559		5117
Hissar		**3697**	**1853**	**41357**	**17713**	**64619**
	Adampur				4521	4521
	Agroha			4824	1608	6432
	Barwala		1853	3706	1853	7411
	Hansi	3697		11090		14787
	Hissar-I			8866		8866
	Hissar-II			8272		8272
	Narnaud			4599	4599	9198
	Uklana				5132	5132
Jhajjar		**6752**		**16160**	**19550**	**42462**
	Bahadurgarh	1702		1702	8508	11911
	Beri			6254	3127	9381
	Jhajjar	5051		5051		10101
	Matanhail			3155	3155	6309
	Salahwas				4760	4760
Jind			**15084**	**17297**	**59709**	**92090**
	Alewa			3525	3525	7049
	Jind		10622		10622	21243
	Julana			4848	4848	9695

(HaM)

District	Block	A	C	E	U	Grand Total
	Narwana		4462	8925	8925	22312
	Safidon				14683	14683
	Uchana				17108	17108
Kaithal			**3067**	**7896**	**37501**	**48464**
	Guhla			2994	2994	5988
	Kaithal			4902	7352	12254
	Kalayat		3067		6134	9201
	Pundri				13414	13414
	Rajond				7607	7607
Karnal		**3025**	**9180**	**24760**	**34981**	**71946**
	Assand				8701	8701
	Gharaunda		3848	3848	1924	9619
	Indri		3037	9111	6074	18222
	Karnal		2295	4591	6886	13772
	Nilokheri	3025		3025	3025	9075
	Nissang			4186	8371	12557
Kurukshetra		**7778**	**17154**	**14570**	**5694**	**45196**
	Babain		4092			4092
	Ladwa	1726	3453			5179
	Pehowa	1779	5337	3558	3558	14233
	Shahbad			6739		6739
	Thanesar	4272	4272	4272	2136	14953
Mahendergarh			**3800**	**608**	**11122**	**15530**
	Kanina		3192		3192	6384
	Mahendergarh		608	608	3649	4865
	Narnaul				4281	4281
Mewat		**3589**		**4205**	**14021**	**21814**
	Ferozpur zirk				5218	5218
	Nagina	2008			2008	4016
	Nuh			2624	2624	5247
	Punhana				4171	4171
	Taoru	1581		1581		3162
Palwal		**2352**	**3482**	**12282**	**21248**	**39364**
	Hathin			2966	7415	10381
	Hodal		1129	2259	6777	10165
	Palwal	2352	2352	7057	7057	18818

(HaM)

District	Block	A	C	E	U	Grand Total
Panchkula		**2359**	**1553**	**4003**	**2678**	**10592**
	Barwala		990	990	990	2971
	Pinjore	2359		1887		4246
	Raipur Rani		563	1125	1688	3375
Panipat			**1788**	**22541**	**8951**	**33281**
	Bapoli			6038		6038
	Israna		1788	5365		7153
	Madlanda			2646	5291	7937
	Panipat			7273		7273
	Samalkha			1220	3660	4880
Rewari				**7894**	**15400**	**23294**
	Bawal			7894		7894
	Khol				3296	3296
	Nahar				5313	5313
	Rewari				6791	6791
Rohtak			**9409**	**17083**	**21303**	**47795**
	Kalanaur			4055	4055	8109
	Lakhan Majra			3256		3256
	Maham		3296		9888	13184
	Rohtak		2453	2453	7360	12267
	Sampla		3660	7319		10979
Sirsa		**4477**	**2375**	**8860**	**26350**	**42061**
	Baragudha				11810	11810
	Dabwali	2375	2375		4749	9498
	Odhan	2102			4204	6306
	Rania				5587	5587
	Sirsa			8860		8860
Sonipat		**830**	**9159**	**21579**	**42638**	**74206**
	Ganaur			6246	12492	18738
	Gohana	830	2490	1660	2490	7470
	Kharkhauda				7066	7066
	Mundlana			4083	12250	16333
	Rai		6669	3335		10004
	Sonipat			6255	8340	14595
Yamunanagar		**6064**		**25557**	**2716**	**34337**
	Chhachroli	3261		9782		13043
	Jagadri	2803		4205	1402	8410
	Radaur			8941		8941
	Sadaura			2629	1314	3943
Grand Total		**46229**	**89959**	**316494**	**423816**	**876498**

Statement 5.1: District-wise estimates of cropland ecosystem services per unit geographic area

(Rs./ha)

State	District	2005-06	2011-12	2014-15
Andaman and Nicobar Islands	ANDAMAN AND NICOBAR ISLANDS	259	379	682
Andhra Pradesh	ADILABAD	1149	1985	NA
	ANANTAPUR	1692	3698	2838
	CHITTOOR	1657	3952	3270
	EAST GODAVARI	4084	7856	12590
	GUNTUR	4230	9596	11430
	KADAPA	948	2719	2220
	KARIMNAGAR	3484	6657	NA
	KHAMMAM	1464	2356	NA
	KRISHNA	5477	10900	13060
	KURNOOL	3004	4013	6470
	MAHBUBNAGAR	1615	4169	NA
	MEDAK	2642	6049	NA
	NALGONDA	2348	4345	NA
	NIZAMABAD	3225	9903	NA
	PRAKASAM	1849	3147	3578
	RANGAREDDI	1569	2518	NA
	SPSR NELLORE	2156	5646	5879
	SRIKAKULAM	2876	7238	8970
	VISAKHAPATANAM	1165	2461	3117
	VIZIANAGARAM	1868	5208	6447
	WARANGAL	2417	4593	NA
	WEST GODAVARI	6895	13717	19607
	HYDERABAD	0	0	NA
Arunachal Pradesh	ANJAW	24	25	62
	CHANGLANG	86	137	220
	DIBANG VALLEY	6	18	22
	EAST KAMENG	37	62	136
	EAST SIANG	144	229	440
	KURUNG KUMEY	29	8	14
	LOHIT	89	162	386
	LONGDING	NA	NA	297
	LOWER DIBANG VALLEY	127	137	301
	LOWER SUBANSIRI	89	52	233
	NAMSAI	NA	NA	9
	PAPUM PARE	89	120	329
	TAWANG	47	53	130
	TIRAP	67	95	125
	UPPER SIANG	29	34	66
	UPPER SUBANSIRI	23	29	66
	WEST KAMENG	20	20	55
	WEST SIANG	56	76	137
Assam	BAKSA	897	1684	3386

(Rs./ha)

State	District	2005-06	2011-12	2014-15
	BARPETA	1198	3821	5351
	BONGAIGAON	1620	2847	4792
	CACHAR	1023	1429	2725
	CHIRANG	516	1056	2298
	DARRANG	1323	3405	5244
	DHEMAJI	529	916	1941
	DHUBRI	1425	3216	5258
	DIBRUGARH	909	1425	2562
	DIMA HASAO	154	350	730
	GOALPARA	1235	2295	4333
	GOLAGHAT	1007	1876	3382
	HAILAKANDI	1186	2137	3738
	JORHAT	1048	1901	3077
	KAMRUP	1401	2140	3511
	KAMRUP METRO	577	1982	3046
	KARBI ANGLONG	371	555	1119
	KARIMGANJ	1152	2535	2705
	KOKRAJHAR	800	1687	3060
	LAKHIMPUR	1128	2990	4720
	MARIGAON	1283	3299	5280
	NAGAON	1785	2578	4863
	NALBARI	1926	3629	7110
	SIVASAGAR	1341	2200	3353
	SONITPUR	955	1750	3221
	TINSUKIA	580	1164	2050
	UDALGURI	931	2078	4348
Bihar	ARARIA	2031	4046	4968
	ARWAL	2590	3556	6753
	AURANGABAD	1662	4735	7447
	BANKA	1593	3414	4407
	BEGUSARAI	2430	3874	4087
	BHAGALPUR	1845	2891	4083
	BHOJPUR	3706	5279	6284
	BUXAR	4510	6123	7500
	DARBHANGA	2002	3184	3946
	GAYA	499	2010	3783
	GOPALGANJ	3035	4933	6849
	JAMUI	265	876	1214
	JEHANABAD	1981	5919	6619
	KAIMUR (BHABUA)	2601	3598	4664
	KATIHAR	2493	4039	6466
	KHAGARIA	3044	4070	4880
	KISHANGANJ	2169	3201	4939
	LAKHISARAI	1386	2935	3998
	MADHEPURA	3094	4698	6873
	MADHUBANI	1196	2820	3917
	MUNGER	1247	1657	2186

(Rs./ha)

State	District	2005-06	2011-12	2014-15
	MUZAFFARPUR	1865	4498	5785
	NALANDA	1810	5135	6475
	NAWADA	783	2673	4141
	PASHCHIM CHAMPARAN	2454	3637	9396
	PATNA	2349	2843	4428
	PURBI CHAMPARAN	2219	4576	5370
	PURNIA	2119	3065	3775
	ROHTAS	4722	5782	8964
	SAHARSA	2735	5527	6634
	SAMASTIPUR	1885	3927	5583
	SARAN	2792	3339	5188
	SHEIKHPURA	1805	3842	7510
	SHEOHAR	2013	7769	7733
	SITAMARHI	1136	3434	6129
	SIWAN	3099	4401	6394
	SUPAUL	2580	2851	5118
	VAISHALI	2411	3697	5921
Chandigarh	CHANDIGARH	1238	2066	1670
Chhattisgarh	BALOD	NA	3994	5845
	BALODA BAZAR	NA	2438	4776
	BALRAMPUR	NA	116	209
	BASTAR	1025	1725	3762
	BEMETARA	NA	6150	8230
	BIJAPUR	NA	385	776
	BILASPUR	1941	3083	4665
	DANTEWADA	429	1074	2318
	DHAMTARI	2076	4250	8799
	DURG	3104	5258	7121
	GARIYABAND	NA	1138	2468
	JANJGIR CHAMPA	3377	7858	11858
	JASHPUR	911	2320	3284
	KABIRDHAM	1309	2735	3536
	KANKER	1145	1482	3962
	KONDAGAON	NA	701	1655
	KORBA	586	1015	1548
	KOREA	329	803	1359
	MAHASAMUND	1571	3455	6237
	MUNGELI	NA	3764	5200
	NARAYANPUR	0	263	574
	RAIGARH	1230	2239	3297
	RAIPUR	1915	3300	7663
	RAJNANDGAON	1524	2840	4008
	SUKMA	NA	675	1768
	SURAJPUR	NA	2838	5074
	SURGUJA	776	1473	2496
Dadra and Nagar Haveli	DADRA AND NAGAR HAVELI	1967	2351	2354

(Rs./ha)

State	District	2005-06	2011-12	2014-15
Daman and Diu	DAMAN	745	1325	2408
	DIU	138	450	433
Delhi	Delhi	1206	0	0
Goa	Goa	1256	1956	2281
Gujarat	AHMADABAD	1496	3521	3549
	AMRELI	1987	1846	1635
	ANAND	3070	6377	8513
	ARAVALLI	NA	NA	3629
	BANAS KANTHA	2050	3954	4485
	BHARUCH	1095	1965	2660
	BHAVNAGAR	2077	2724	3311
	BOTAD	NA	NA	1504
	CHHOTAUDEPUR	NA	NA	3972
	DANG	1096	1936	1842
	DEVBHUMI DWARKA	NA	NA	4634
	DOHAD	1983	3188	3471
	GANDHINAGAR	2085	3449	3713
	GIR SOMNATH	NA	NA	8278
	JAMNAGAR	1725	3829	4315
	JUNAGADH	4104	8112	11374
	KACHCHH	230	542	302
	KHEDA	2887	5492	5991
	MAHESANA	2038	3989	3065
	MAHISAGAR	NA	NA	3797
	MORBI	NA	NA	1768
	NARMADA	1052	2726	2339
	NAVSARI	3040	5485	5815
	PANCH MAHALS	1280	2507	1732
	PATAN	1165	1765	1422
	PORBANDAR	2992	6289	4686
	RAJKOT	3158	4614	2102
	SABAR KANTHA	2021	3451	4030
	SURAT	3675	7207	6772
	SURENDRANAGAR	951	2236	1607
	TAPI	NA	3297	4722
	VADODARA	1372	3214	1274
	VALSAD	1794	2539	3115
Haryana	AMBALA	7322	14360	17009
	BHIWANI	2500	8248	9731
	FARIDABAD	3818	6759	6497
	FATEHABAD	6653	14736	18561
	GURGAON	3113	7245	5993
	HISAR	4300	10778	11320
	JHAJJAR	3917	9810	11043
	JIND	6808	14268	15542
	KAITHAL	8386	16144	20389
	KARNAL	8697	16188	20073

(Rs./ha)

State	District	2005-06	2011-12	2014-15
	KURUKSHETRA	11272	20806	25980
	MAHENDRAGARH	3729	7504	9607
	MEWAT	4239	8015	7787
	PALWAL	NA	11792	12461
	PANCHKULA	1561	3172	4130
	PANIPAT	7349	15007	13575
	REWARI	3994	9642	9375
	ROHTAK	4268	10309	10761
	SIRSA	4789	10667	15249
	SONIPAT	6275	14065	13817
	YAMUNANAGAR	7539	13487	17060
Himachal Pradesh	BILASPUR	507	1343	1627
	CHAMBA	125	329	557
	HAMIRPUR	858	1478	2042
	KANGRA	618	961	1806
	KINNAUR	21	50	75
	KULLU	246	351	550
	LAHUL AND SPITI	9	22	27
	MANDI	726	836	1278
	SHIMLA	336	530	699
	SIRMAUR	413	749	1255
	SOLAN	634	730	1889
	UNA	678	1281	2381
Jammu and Kashmir	ANANTNAG	662	717	582
	BADGAM	989	1511	1595
	BANDIPORA	NA	312	282
	BARAMULLA	285	523	530
	DODA	98	83	107
	GANDERBAL	NA	2625	2362
	JAMMU	1382	2666	3038
	KARGIL	NA	14	38
	KATHUA	764	1654	1598
	KISHTWAR	NA	166	278
	KULGAM	NA	3845	3409
	KUPWARA	317	379	574
	LEH LADAKH	6	4	12
	POONCH	442	491	773
	PULWAMA	1045	2074	1246
	RAJAURI	622	914	1009
	RAMBAN	NA	447	354
	REASI	NA	396	571
	SAMBA	NA	1767	1890
	SHOPIAN	NA	1535	1726
	SRINAGAR	353	210	321
	UDHAMPUR	349	816	883
Jharkhand	BOKARO	71	727	1433
	CHATRA	139	430	1401

(Rs./ha)

State	District	2005-06	2011-12	2014-15
	DEOGHAR	168	950	1526
	DHANBAD	172	387	731
	DUMKA	627	906	2030
	EAST SINGHBUM	342	1453	3084
	GARHWA	178	717	1091
	GIRIDIH	144	551	1064
	GODDA	796	758	2136
	GUMLA	478	960	1470
	HAZARIBAGH	242	694	1532
	JAMTARA	166	1256	1866
	KHUNTI	NA	937	2544
	KODERMA	91	184	315
	LATEHAR	147	373	500
	LOHARDAGA	432	1605	2380
	PAKUR	677	905	2230
	PALAMU	216	689	1617
	RAMGARH	NA	585	1021
	RANCHI	344	1388	2514
	SAHEBGANJ	408	601	1690
	SARAIKELA KHARSAWAN	298	831	3080
	SIMDEGA	312	998	1949
	WEST SINGHBHUM	203	643	1523
Karnataka	BAGALKOT	2924	7673	10049
	BANGALORE RURAL	1455	2858	3444
	BELGAUM	2611	6743	8326
	BELLARY	1995	4159	5994
	BENGALURU URBAN	972	1327	1801
	BIDAR	1808	4109	4538
	BIJAPUR	1542	3388	6457
	CHAMARAJANAGAR	1008	2439	2519
	CHIKBALLAPUR	NA	2532	2607
	CHIKMAGALUR	1119	2119	3356
	CHITRADURGA	1466	2768	4901
	DAKSHIN KANNAD	923	2182	3411
	DAVANGERE	3489	7541	10055
	DHARWAD	1832	3585	6386
	GADAG	2181	3385	6741
	GULBARGA	2209	4093	7535
	HASSAN	1770	3851	5749
	HAVERI	1903	4999	6263
	KODAGU	723	1678	2609
	KOLAR	1177	1968	2104
	KOPPAL	2492	4339	7596
	MANDYA	2585	6834	7066
	MYSORE	2704	5144	5815
	RAICHUR	2174	3530	5927

(Rs./ha)

State	District	2005-06	2011-12	2014-15
	RAMANAGARA	NA	2895	3773
	SHIMOGA	1342	3094	3582
	TUMKUR	1786	3387	5327
	UDUPI	1302	2609	4563
	UTTAR KANNAD	457	891	1322
	YADGIR	NA	2685	5267
Kerala	ALAPPUZHA	4552	8750	11472
	ERNAKULAM	2948	5849	8002
	IDUKKI	1625	5498	5848
	KANNUR	4123	8574	10827
	KASARAGOD	3753	9460	16446
	KOLLAM	3874	7406	9741
	KOTTAYAM	4294	9862	12845
	KOZHIKODE	5218	10515	17033
	MALAPPURAM	4023	8632	12274
	PALAKKAD	3121	7042	9066
	PATHANAMTHITTA	1759	4407	5380
	THIRUVANANTHAPURAM	5009	9429	14606
	THRISSUR	3925	7096	8836
	WAYANAD	2164	6021	7965
Madhya Pradesh	AGAR MALWA	NA	NA	4711
	ALIRAJPUR	NA	2041	5052
	ANUPPUR	1003	1648	3744
	ASHOKNAGAR	2119	6229	6808
	BALAGHAT	1126	1985	2452
	BARWANI	500	2161	7093
	BETUL	1357	3108	4596
	BHIND	3064	6227	8511
	BHOPAL	2633	6032	7380
	BURHANPUR	596	1666	2787
	CHHATARPUR	1364	3381	3151
	CHHINDWARA	1254	4611	3069
	DAMOH	1429	2959	2997
	DATIA	2884	6387	10590
	DEWAS	2647	6640	6757
	DHAR	1997	5152	6428
	DINDORI	471	859	2053
	GUNA	1729	5001	5633
	GWALIOR	2660	5788	5149
	HARDA	4545	11126	12101
	HOSHANGABAD	2850	7624	8806
	INDORE	2679	9231	9058
	JABALPUR	2060	3990	4513
	JHABUA	976	2112	4356
	KATNI	1015	2838	3473
	KHANDWA	1000	2417	1540

(Rs./ha)

State	District	2005-06	2011-12	2014-15
	KHARGONE	807	2208	3301
	MANDLA	748	1814	2113
	MANDSAUR	1628	6820	6254
	MORENA	3335	7091	7267
	NARSINGHPUR	3065	5824	6015
	NEEMUCH	1663	3316	4195
	PANNA	830	2417	2279
	RAISEN	1893	4840	7127
	RAJGARH	2244	5524	8429
	RATLAM	2541	5786	5706
	REWA	1677	3783	6723
	SAGAR	1492	4016	2813
	SATNA	1425	3094	5722
	SEHORE	2953	7352	8238
	SEONI	1188	3019	3238
	SHAHDOL	623	1885	2805
	SHAJAPUR	2554	6619	7818
	SHEOPUR	1182	3377	3774
	SHIVPURI	1586	4980	5193
	SIDHI	665	1857	2792
	SINGRAULI	NA	1230	2475
	TIKAMGARH	1645	4652	4346
	UJJAIN	2991	8972	7546
	UMARIA	497	1164	2186
	VIDISHA	2640	5937	7772
Maharashtra	AHMEDNAGAR	1233	4135	5151
	AKOLA	1556	3937	3350
	AMRAVATI	1083	3022	2907
	AURANGABAD	1548	3851	2386
	BEED	1473	3671	2897
	BHANDARA	1416	3054	3911
	BULDHANA	905	3908	3374
	CHANDRAPUR	789	1456	1614
	DHULE	878	3028	4287
	GADCHIROLI	296	491	602
	GONDIA	1013	2025	2878
	HINGOLI	2257	4719	6497
	JALGAON	1553	3548	4972
	JALNA	1664	3356	1979
	KOLHAPUR	2738	8564	10481
	LATUR	2913	7076	5630
	NAGPUR	1126	2320	2683
	NANDED	1197	3821	2082
	NANDURBAR	919	3352	2684
	NASHIK	961	2815	2820
	OSMANABAD	2072	6095	4070
	PALGHAR	NA	NA	1454

(Rs./ha)

State	District	2005-06	2011-12	2014-15
	PARBHANI	2050	5697	4359
	PUNE	1405	4246	5100
	RAIGAD	755	1420	1887
	RATNAGIRI	456	951	1096
	SANGLI	1692	4690	7546
	SATARA	1487	4518	5403
	SINDHUDURG	807	1396	1694
	SOLAPUR	1430	4710	6921
	THANE	626	1227	1315
	WARDHA	1339	2864	2589
	WASHIM	1755	4203	3709
	YAVATMAL	1032	2733	1850
	MUMBAI CITY	0	0	0
	SUBURBAN MUMBAI	0	0	0
Manipur	BISHNUPUR	1452	5787	7401
	CHANDEL	76	195	405
	CHURACHANDPUR	126	238	559
	IMPHAL EAST	1423	3649	4534
	IMPHAL WEST	1816	5792	7370
	SENAPATI	329	222	449
	TAMENGLONG	41	210	464
	THOUBAL	1515	5667	7096
	UKHRUL	130	138	257
Meghalaya	EAST GARO HILLS	272	386	699
	EAST JAINTIA HILLS	104	134	317
	EAST KHASI HILLS	380	576	1429
	NORTH GARO HILLS	NA	NA	884
	RI BHOI	236	407	769
	SOUTH GARO HILLS	171	394	719
	SOUTH WEST GARO HILLS	NA	NA	2983
	SOUTH WEST KHASI HILLS	NA	NA	754
	WEST GARO HILLS	525	1054	1767
	WEST JAINTIA HILLS	NA	NA	804
	WEST KHASI HILLS	125	208	396
Mizoram	AIZAWL	108	132	357
	CHAMPHAI	124	111	308
	KOLASIB	251	251	889
	LAWNGTLAI	87	80	286
	LUNGLEI	74	116	221
	MAMIT	85	131	313
	SAIHA	119	121	465
	SERCHHIP	111	257	934
Nagaland	MON	345	844	1365
	DIMAPUR	2340	3253	5462
	KIPHIRE	NA	802	1461

(Rs./ha)

State	District	2005-06	2011-12	2014-15
	KOHIMA	726	919	1616
	LONGLENG	NA	1033	1770
	MOKOKCHUNG	454	867	1352
	PEREN	NA	700	1157
	PHEK	495	707	1346
	TUENSANG	409	588	1041
	WOKHA	470	865	1416
	ZUNHEBOTO	503	922	1659
Odisha	ANUGUL	954	901	1941
	BALANGIR	1375	1081	5594
	BALESHWAR	2223	8822	6821
	BARGARH	2265	7708	8187
	BHADRAK	2922	7583	4951
	BOUDH	889	1681	2339
	CUTTACK	2073	5140	4598
	DEOGARH	696	1401	2601
	DHENKANAL	1497	3006	3927
	GAJAPATI	484	713	937
	GANJAM	1439	1449	4766
	JAGATSINGHAPUR	2746	8757	7234
	JAJAPUR	2498	4005	4872
	JHARSUGUDA	1254	1473	2423
	KALAHANDI	1192	1882	3886
	KANDHAMAL	370	378	599
	KENDRAPARA	2366	5745	4178
	KENDUJHAR	1003	2333	2585
	KHORDHA	1837	3598	4290
	KORAPUT	939	1607	2092
	MALKANGIRI	660	689	1783
	MAYURBHANJ	1112	3582	3393
	NABARANGPUR	1156	1806	4574
	NAYAGARH	1220	1172	3119
	NUAPADA	998	1473	2869
	PURI	1915	4549	4768
	RAYAGADA	495	940	1838
	SAMBALPUR	1086	2436	3249
	SONEPUR	2381	8129	9512
	SUNDARGARH	725	2368	2665
Puducherry	KARAIKAL	2064	3336	2459
	MAHE	5737	6377	NA
	PONDICHERRY	5559	5005	8436
	YANAM	3562	3651	4877
Punjab	AMRITSAR	9563	18851	18361
	BARNALA	NA	23928	27727
	BATHINDA	7711	16418	20274
	FARIDKOT	10300	21903	25797
	FATEHGARH SAHIB	11379	25407	25244

(Rs./ha)

State	District	2005-06	2011-12	2014-15
	FAZILKA	NA	559	15601
	FIROZEPUR	8867	34816	25916
	GURDASPUR	8430	32789	18662
	HOSHIARPUR	5439	19408	11995
	JALANDHAR	10500	24402	21815
	KAPURTHALA	10913	23523	22509
	LUDHIANA	12222	24189	25797
	MANSA	7722	16607	18063
	MOGA	11509	24361	28321
	MUKTSAR	8130	17709	21322
	NAWANSHAHR	8153	24667	18578
	PATHANKOT	NA	19021	9377
	PATIALA	11528	22784	23090
	RUPNAGAR	9050	14946	12654
	S.A.S NAGAR	NA	15197	11676
	SANGRUR	11587	25186	29260
	TARN TARAN	NA	18766	20919
Rajasthan	AJMER	320	1878	2375
	ALWAR	2824	5095	6344
	BANSWARA	1565	2317	2968
	BARAN	2220	4287	4490
	BARMER	110	571	543
	BHARATPUR	3830	6836	7578
	BHILWARA	777	2013	2677
	BIKANER	309	1136	1416
	BUNDI	2393	4835	4405
	CHITTORGARH	2490	3262	4030
	CHURU	256	1029	1439
	DAUSA	2903	5235	7078
	DHOLPUR	2529	4553	5063
	DUNGARPUR	531	1238	2163
	GANGANAGAR	2406	4305	4926
	HANUMANGARH	2210	4137	5038
	JAIPUR	2141	3761	4441
	JAISALMER	137	243	196
	JALORE	731	1840	2049
	JHALAWAR	1812	3768	4113
	JHUNJHUNU	2082	3767	5036
	JODHPUR	398	1610	2357
	KARAULI	1722	3105	4093
	KOTA	2510	4467	3474
	NAGAUR	1027	2068	2201
	PALI	342	1284	1764
	PRATAPGARH	NA	2498	3468
	RAJSAMAND	550	1183	1561
	SAWAI MADHOPUR	2464	3949	5173
	SIKAR	1715	3578	4421

(Rs./ha)

State	District	2005-06	2011-12	2014-15
	SIROHI	687	1184	1238
	TONK	1840	3838	3578
	UDAIPUR	621	1100	1398
Sikkim	EAST DISTRICT	711	522	1161
	NORTH DISTRICT	32	26	65
	SOUTH DISTRICT	866	671	2077
	WEST DISTRICT	718	462	1248
Tamil Nadu	ARIYALUR	NA	4184	5296
	COIMBATORE	3823	3208	5400
	CUDDALORE	3357	4906	10360
	DHARMAPURI	1999	3788	3731
	DINDIGUL	1899	3649	4614
	ERODE	3334	3302	3944
	KANCHIPURAM	2248	3130	2593
	KANNIYAKUMARI	4607	3329	10081
	KARUR	1393	3006	3124
	KRISHNAGIRI	1309	2668	3821
	MADURAI	2443	3817	4037
	NAGAPATTINAM	2087	8002	8671
	NAMAKKAL	2970	4248	6850
	PERAMBALUR	2211	6115	7619
	PUDUKKOTTAI	1968	3403	2931
	RAMANATHAPURAM	1819	3469	4191
	SALEM	2090	3993	5534
	SIVAGANGA	1372	2816	2021
	THANJAVUR	5300	9730	10951
	THE NILGIRIS	689	1070	2273
	THENI	3336	4695	5372
	THIRUVALLUR	2714	3783	5143
	THIRUVARUR	3343	11833	14605
	TIRUCHIRAPPALLI	2122	3408	4021
	TIRUNELVELI	1783	2917	3778
	TIRUPPUR	NA	3535	4160
	TIRUVANNAMALAI	2589	4031	4535
	TUTICORIN	1256	2717	4200
	VELLORE	2068	2636	3536
	VILLUPURAM	3402	5068	8911
	VIRUDHUNAGAR	1280	2444	3709
	CHENNAI	0	0	0
Telangana	ADILABAD	NA	NA	1815
	KARIMNAGAR	NA	NA	7656
	KHAMMAM	NA	NA	2916
	MAHBUBNAGAR	NA	NA	5368
	MEDAK	NA	NA	5692
	NALGONDA	NA	NA	5342
	NIZAMABAD	NA	NA	7907
	RANGAREDDI	NA	NA	2831

(Rs./ha)

State	District	2005-06	2011-12	2014-15
	WARANGAL	NA	NA	4652
	HYDERABAD	NA	NA	0
Tripura	Tripura	888	1726	2822
Uttar Pradesh	AGRA	4294	8349	10248
	ALIGARH	5282	10684	12332
	ALLAHABAD	2943	5652	5113
	AMBEDKAR NAGAR	5094	9655	10696
	AMETHI	NA	8289	6006
	AMROHA	6295	11222	13727
	AURAIYA	4422	9556	10984
	AZAMGARH	4399	9015	10259
	BAGHPAT	7765	17405	21226
	BAHRAICH	3056	5844	7767
	BALLIA	3483	8166	8641
	BALRAMPUR	3697	6855	7390
	BANDA	2195	4608	3032
	BARABANKI	4481	7992	9623
	BAREILLY	5717	11237	12314
	BASTI	4084	9681	9631
	BIJNOR	6515	12125	14574
	BUDAUN	4808	9488	11322
	BULANDSHAHR	4847	9994	11003
	CHANDAULI	2913	6126	7215
	CHITRAKOOT	1318	3019	1880
	DEORIA	4304	8920	9402
	ETAH	7712	9308	9848
	ETAWAH	4174	8245	8130
	FAIZABAD	3970	8800	9693
	FARRUKHABAD	4339	7286	8363
	FATEHPUR	3026	7013	6199
	FIROZABAD	5084	9557	11437
	GAUTAM BUDDHA NAGAR	4088	6172	5541
	GHAZIABAD	10750	19922	9960
	GHAZIPUR	3990	7735	8644
	GONDA	4394	9211	10697
	GORAKHPUR	3789	7872	8068
	HAMIRPUR	2315	3886	3257
	HAPUR	NA	NA	27419
	HARDOI	4029	8421	8746
	HATHRAS	4890	8955	12309
	JALAUN	3029	5277	3081
	JAUNPUR	3643	8109	8941
	JHANSI	2212	5411	3699
	KANNAUJ	4385	7866	8000
	KANPUR DEHAT	4067	8040	6019
	KANPUR NAGAR	2855	6053	4715

(Rs./ha)

State	District	2005-06	2011-12	2014-15
	KASGANJ	NA	9599	12220
	KAUSHAMBI	3093	6842	6149
	KHERI	5102	10071	12928
	KUSHI NAGAR	5373	10466	11164
	LALITPUR	1734	4762	6020
	LUCKNOW	2491	4323	4908
	MAHARAJGANJ	4259	9523	11012
	MAHOBA	1971	3370	2579
	MAINPURI	4240	9815	11440
	MATHURA	5351	9365	9060
	MAU	4246	8856	9005
	MEERUT	8246	14766	18436
	MIRZAPUR	1474	3442	4510
	MORADABAD	6253	10606	7283
	MUZAFFARNAGAR	8600	16175	17509
	PILIBHIT	5513	10716	13547
	PRATAPGARH	2149	5409	5353
	RAE BARELI	2870	4401	5539
	RAMPUR	5886	11923	12021
	SAHARANPUR	6306	11090	12631
	SAMBHAL	NA	NA	11974
	SANT KABEER NAGAR	4112	8416	9770
	SANT RAVIDAS NAGAR	2832	6946	7027
	SHAHJAHANPUR	6191	11414	12184
	SHAMLI	NA	NA	22153
	SHRAVASTI	3425	6654	9215
	SIDDHARTH NAGAR	4332	9410	10965
	SITAPUR	4515	9370	11776
	SONBHADRA	513	1100	1722
	SULTANPUR	3594	7266	7433
	UNNAO	3145	6229	6717
	VARANASI	3161	6965	7412
Uttarakhand	ALMORA	317	1036	1197
	BAGESHWAR	320	678	672
	CHAMOLI	81	210	226
	CHAMPAWAT	319	576	658
	DEHRADUN	638	1293	1316
	HARIDWAR	3827	7303	9045
	NAINITAL	627	1251	1345
	PAURI GARHWAL	167	520	599
	PITHORAGARH	182	361	427
	RUDRA PRAYAG	194	577	628
	TEHRI GARHWAL	294	693	850
	UDAM SINGH NAGAR	4935	11036	11686
	UTTAR KASHI	102	204	219
West Bengal	24 PARAGANAS NORTH	4119	6934	10037
	24 PARAGANAS SOUTH	1450	2799	4028

(Rs./ha)

State	District	2005-06	2011-12	2014-15
	ALIPURDUAR	NA	NA	53
	BANKURA	2703	4971	6301
	BIRBHUM	4325	7635	10580
	COOCHBEHAR	4029	8358	14343
	DARJEELING	2001	2663	4563
	DINAJPUR DAKSHIN	6145	7761	10781
	DINAJPUR UTTAR	4695	8942	15396
	HOOGHLY	8746	12860	20863
	HOWRAH	4087	6203	10311
	JALPAIGURI	2340	4541	13499
	MALDAH	4106	7116	10595
	MEDINIPUR EAST	2679	7155	9097
	MEDINIPUR WEST	3683	6139	9981
	MURSHIDABAD	6200	9893	14887
	NADIA	5896	10681	14891
	PURBA BARDHAMAN	4933	7671	11197
	PURULIA	1392	3142	3604
	KOLKATA	0	0	0

Appendix –I

Functions / Effects of key nutrients available in soil

Nitrogen (N)	*Function*	Nitrogen is needed for synthesis of all proteins in plants. These are needed for the synthesis of enzymes which control all the essential processes in any living organism (example: photosynthesis, respiration, growth).
	Deficiency symptoms	Light green leaf and plant colour with the older leaves turning yellow, leaves that will eventually turn brown and die. Plant growth is slow, plants will be stunted, and will mature early.
	Excess symptoms	Plants will be dark green in colour and new growth will be succu-lent; susceptible if subjected to disease and insect infestation; and subjected to drought stress, plants will easily lodge. Blossom abortion and lack of fruit set will occur.
Phosphorus (P)	*Function*	Phosphorus helps transfer energy from sunlight to plants, stimulates early root and plant growth, and hastens maturity
	Deficiency symptoms	Plant growth will be slow and stunted, and the older leaves will have a purple colouration, particularly on the underside.
	Excess symptoms	Phosphorus excess will not have a direct effect on the plant but may show visual deficiencies of Zn, Fe, and Mn. High P may also interfere with the normal Ca nutrition, with typical Ca deficiency symptoms occurring.
Potassium (K)	*Function*	Potassium increases vigour and disease resistance of plants, helps form and move starches, sugars and oils in plants, and can improve fruit quality.
	Deficiency symptoms	Edges of the older leaves look burned, a symptom known as scorch. Plants will easily lodge and be sensitive to disease infestation. Fruit and seed production will be impaired and of poor quality.
	Excess symptoms	Plants will exhibit typical Magnesium and calcium deficiency symptoms due to a cation imbalance
Sulphur (S)	*Function*	Sulphur is a constituent of amino acids in plant proteins and is involved in energy-producing processes in plants. It is responsible for many flavour and odour compounds in plants.
	Deficiency symptoms	A general overall light green colour of the entire plant with the older leaves being light green to yellow in colour as the deficiency intensifies.

	Excess symptoms	A premature senescence of leaves may occur.
Boron (B)	*Function*	Boron helps with the formation of cell walls in rapidly growing tissue.
	Deficiency symptoms	Abnormal development of the growing points (meristematic tissue) with the apical growing points eventually becoming stunted and dying. Rowers and fruits will abort. For some grain and fruit crops, yield and quality is significantly reduced.
	Excess symptoms	Leaf tips and margins will turn brown and die.
Zinc (Zn)	*Function*	Zinc helps in the production of a plant hormone responsible for stem elongation and leaf expansion.
	Deficiency symptoms	Upper leaves will show interveinal chlorosis with an eventual whiting of the affected leaves. Leaves may be small and distorted with a rosette form.
	Excess symptoms	An Fe deficiency will develop.
Manganese (Mn)	*Function*	Manganese helps with photosynthesis.
	Deficiency symptoms	Interveinal chlorosis of young leaves while the leaves and plants remain generally green in colour. When severe, the plants will be stunted.
	Excess symptoms	Older leaves will show brown spots surrounded by a chlorotic zone and circle.
Iron (Fe)	*Function*	Iron plays an important role in plant respiratory and photosynthetic reactions.
	Deficiency symptoms	Interveinal chlorosis will occur on the emerging and young leaves with eventual bleaching of the new growth. When severe, the entire plant may be light green in colour.
	Excess symptoms	A bronzing of leaves with tiny brown spots on the leaves, a typical symptom frequently occurring with rice.
Copper (Cu)	*Function*	Copper is an essential constituent of enzymes in plants. It is needed for chlorophyll production, respiration and protein synthesis.
	Deficiency symptoms	Plant growth will be slow and plants stunted with distortion of the young leaves and death of the growing point.
	Excess symptoms	An Fe deficiency may be induced with very slow growth. Roots may be stunted.

Impact of Some Determinants of Water Quality[1]

S. No.	Parameters	Impact on Human Health	Impact on Livestock	Impact on Irrigation water/ Plant Growth	Impact on Industries
1	pH	The pH level should be in the range 7–7.2. If pH is less than 5.3, assimilation of vitamins or minerals is not possible; hence, it should be above 6.4. If pH is greater than 8.5, it causes the water to taste bitter or soda-like taste. And causes eye irritation and exacerbation of skin disorder, if the pH is greater than 11. pH in the range of 10–12.5 cause hair fibers to swell. pH in the range 3.5–4.5 affects the fish reproduction.			Low pH increases corrosion of concrete; pH 7 is required for most industries, pH 6.7-7.2 is advised for carbonated beverage industry.
2	Dissolved oxygen		Very low dissolved oxygen in water has adverse effects on most flora and fauna including fish and might lead to extinction.		

[1] Water Quality Issues and Challenges in Punjab (March 2014), Central Ground Water Board, Ministry of Water Resources

S. No.	Parameters	Impact on Human Health	Impact on Livestock	Impact on Irrigation water/ Plant Growth	Impact on Industries
3	**Total coliform**	The main cause of water borne diseases and enteric diseases is the contamination of source with intestinal pathogenic micro-organisms.			
4	**Electrical conductivity**			The effects of salinity are stunted plant growth, low yield, discoloration and even leaf burns at margin or top. Plant growth is retarded with stunted fruits, leaves and stem in high salinity.	
5	**Boron**	Affects central nervous system and its salt may cause nausea, cramps, convulsions, coma etc.	No definite effect	Boron is an essential plant nutrient but concentration above 4.0 mg/l is toxic to plant.	
6	**Sodium Adsorption Ratio**			Causes deflocculation of soil, restricting free movement of water.	
7	**Nitrate**	Nitrate at very high concentration may cause infant methaemoglobinaemia (blue babies), causes gastric cancer and affects adversely central nervous system and cardiovascular system.	Leads to methaemoglobinaemia, erosion and haemorrhage of gastric mucosa leading to death. Cause reduction in plasma and vitamin A in liver.	An essential plant nutrient but its excess may delay maturity and seed growth in some plants.	Nitrate above 30 mg/l is injurious to dyeing of wool and silk fabrics and harmful in fermentation process for brewing.

S. No.	Parameters	Impact on Human Health	Impact on Livestock	Impact on Irrigation water/ Plant Growth	Impact on Industries
8	**Fluoride**	Fluoride less than 1.0 mg/l is desirable in drinking water as it prevents dental carries but with very high concentration may cause crippling skeletal fluorosis.	Fluoride above 2.0 mg/l may cause tooth mottling and is also transferred into milk and eggs.		Fluoride above 1.0 mg/l is harmful in industries involved in production of food, beverages, pharmaceuticals and medical items.
9	**Arsenic**	Arsenic is a recognized carcinogenic element. The gastrointestinal tract, nervous system, respiratory tract and skin can be severely affected. Chronic poisoning is manifested by general muscular weakness, loss of appetite and nausea, leading to inflammation of mucous membrane in the eye, nose and larynx, skin lesions may also occur. Neurological manifestations and even malignant tumours in vital organs may also be observed.			

S. No.	Parameters	Impact on Human Health	Impact on Livestock	Impact on Irrigation water/ Plant Growth	Impact on Industries
10	**Total Dissolved Solids**	Palatability decreases and may cause gastro-intestinal irritation in human, may have laxative effect particularly upon transits and corrosion, may damage water system.			Total dissolved solids above 3000 mg/l cause foaming in boilers and solids interfere with cleanliness, colour or taste of finished products. Low TDS values are required in most industries, high TDS leads to corrosion.
11	**Total Hardness (as $CaCO_3$)**	Hardness, when present more than 600 mg/l may affect water supply system (Scaling), lead to excessive soap consumption, calcification of arteries. It may also cause urinary concretions, diseases of kidney or bladder and stomach disorder.			

S. No.	Parameters	Impact on Human Health	Impact on Livestock	Impact on Irrigation water/ Plant Growth	Impact on Industries
12	**Iron (as Fe)**	In cases of High Iron concentration (> 1.0mg/l) in water, excess iron stored in Spleen, Liver, Bone marrow & causes Haemochromatosis.[2]		Deficiency caused by excess of lime in soils, results in chlorosis. Excess iron contributes to soil acidification.	Recommended value of Iron for food processing units is 0.2mg/l, for paper and photographic industry iron of 0.1 mg/l is recommended, iron less than 0.1 mg/l is recommended in cooling waters.
13	**Chlorides (as Cl)**	May be injurious to some people suffering from diseases of heart or kidneys. Taste, indigestion, corrosion and palatability are affected.		May have direct toxic effects along with sodium.	Significantly affect the rate of corrosion of steel and aluminium.
14	**Sulphate (as SO_4)**	Causes gastro intestinal irritation. Along with Mg or Na, can have a cathartic effect on users, concentration more than 750 mg/l may have laxative effect along with Magnesium.			Increases corrosiveness of water towards concrete, low sulphate (20mg/l) is recommended for sugar industries.

[2] Concept Note On Geogenic Contamination Of Ground Water In India, With a special note on Nitrate (February 2014) , Central Ground Water Board, Ministry of Water Resources, http://cgwb.gov.in/WQ/Geogenic%20Final.pdf

S. No.	Parameters	Impact on Human Health	Impact on Livestock	Impact on Irrigation water/ Plant Growth	Impact on Industries
15	**Calcium (as Ca)**	While insufficiency causes a severe type of rickets, excess causes concretions in the body such as kidney or bladder stones and irritation in urinary passages.			Has undesirable effects like forming scale, precipitates and curds in industry. It may interfere in formation of emulsions and processing of colloids upsetting fermentation process and electroplating rinsing operations.
16	**Magnesium (as Mg)**	Its salts are cathartics and diuretic. High conc. may have laxative effect. Magnesium deficiency is associated with structural and functional changes. It is essential as an activator of many enzyme systems.			No definite effect

S. No.	Parameters	Impact on Human Health	Impact on Livestock	Impact on Irrigation water/ Plant Growth	Impact on Industries
17	**Sodium Percentage**			High sodium in water affects the permeability of soil and causes infiltration problems Other problems caused by an excess of Na is the formation of crusting seed beds, temporary saturation of the surface soil, high pH and the increased potential for diseases, weeds, soil erosion, lack of oxygen and inadequate nutrient availability.	
18	**Residual Sodium Carbonate (RSC)**			When water having high bicarbonates and low calcium and magnesium is used for irrigation purpose, precipitation of calcium and magnesium as carbonate takes place, changing the residual water to high sodium water with sodium bicarbonate in solution.	

Appendix-III

Threshold limits for quality parameters for surface water[3]

DESIGNATED BEST USE	Class of Water	CRITERIA
Drinking Water Source without conventional treatment but after disinfection	A	Total Coliforms Organism MPN/100ml - 50 or less pH between 6.5 and 8.5 Dissolved Oxygen 6mg/l or more Biochemical Oxygen Demand 5 days 20^{0}C 2mg/l or less Arsenic (mg/L) – max 0.01[4] Fluoride (mg/L)- max 1.0[4] Nitrate, Nitrogen (mgN/L)- 45 (limit taken that for Nitrate) [4]
Outdoor bathing (Organised)	B	Total Coliforms Organism MPN/100ml - 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more Biochemical Oxygen Demand 5 days 20^{0}C 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	Total Coliforms Organism MPN/100ml - 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more Biochemical Oxygen Demand 5 days 20^{0}C 3mg/l or less Arsenic (mg/L) - max 0.01[4] Fluoride (mg/L)- max 1.5[4] Nitrate, Nitrogen (mgN/L)- 45 (limit taken that for Nitrate) [4]
Propagation of Wild life and Fisheries	D	pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	pH between 6.0 to 8.5 Electrical Conductivity at 25^{0}C micro mhos/cm Max.2250 Sodium absorption Ratio Max. 26 Boron Max. 2mg/l
Unclassified	U	

[3] Status of Water Quality in India 2011, Central Pollution Control Board (CPCB), Ministry of Environment & Forests

[4] BIS, I. (2012). 10500: 2012 Indian Standard Drinking Water-Specification (Second revision). Bureau of Indian Standards (BIS), New Delhi.

Appendix – IV

Threshold limits for quality parameters for ground water

DESIGNATED BEST USE	Class of Water	CRITERIA
Drinking Water Source – Class I, as defined by the acceptable limits of IS 10500:2012[4]	A	pH between 6.5 to 8.5 Total Dissolved Solids, mg/l, Max- 500 Total Hardness (as $CaCO_3$), mg/l, Max- 200 Iron (as Fe), mg/l, Max- 1.0 Chlorides (as Cl), mg/l, Max- 250 Sulphate (as SO_4), mg/l, Max - 200 Fluorides (as F), mg/l, Max- 1.0 Arsenic (as As), mg/l, Max- 0.01 Nitrates (as NO_3), mg/l, Max- 45 Calcium (as Ca), mg/l, Max- 75 Magnesium (as Mg), mg/l, Max- 30 Bicarbonate- 244[5]
Drinking Water Source – Class II, as defined by the permissible limits of IS 10500:2012[4]	C	pH between 6.5 to 8.5 Total Dissolved Solids, mg/l, Max- 2000 Total Hardness (as $CaCO_3$), mg/l, Max- 600 Iron (as Fe), mg/l, Max- 1.0 Chlorides (as Cl), mg/l, Max- 1000 Sulphate (as SO_4), mg/l, Max- 400 Fluorides (as F), mg/l, Max- 1.5 Arsenic (as), mg/l, Max- 0.01 Nitrates (as NO_3), mg/l, Max- 45 Calcium (as Ca), mg/l, Max- 200 Magnesium (as Mg), mg/l, Max- 100 Bicarbonate- 732[5]
Irrigation, Water as defined by the IS 11624 (1986 reaffirmed 2009)[6]	E	Electrical Conductance at 25° C, µS Max- 3000 Sodium Adsorption Ratio, Max- 18 Sodium Percentage, Max- 60[7] RSC, meq/l, Max- 3.0
Unclassified	U	

[5] As suggested by CGWB

[6] IS 11624: 1986 (Reaffirmed 2009), Guidelines for quality of irrigation water, Bureau of Indian Standards

[7] Water Quality Year Book, Yamuna Basin, 2016-17, CWC